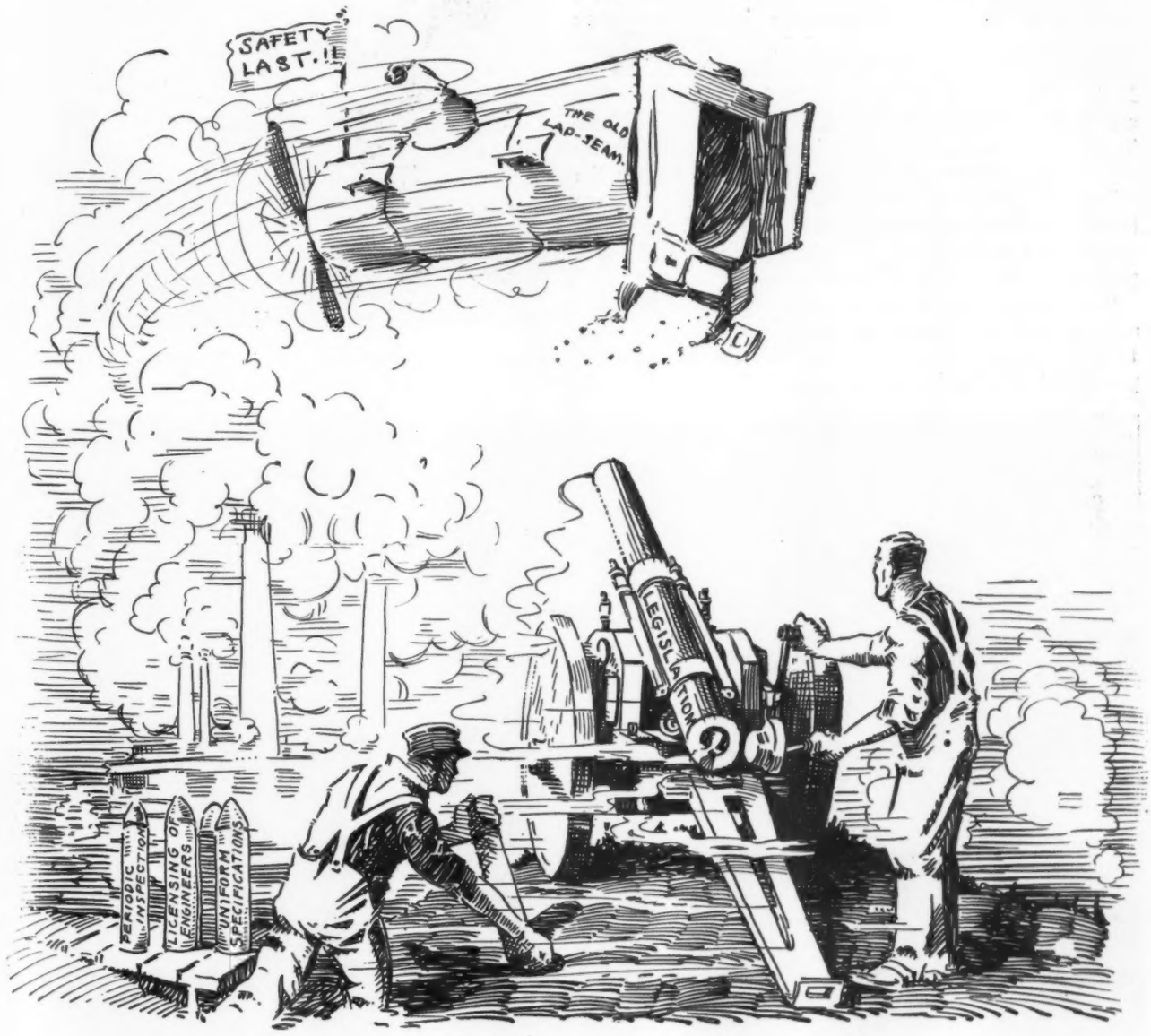
POWER

Vol. 41 NEW YORK, MAY 25, 1915 No. 21

How to Bring Down the Game



In the engineer's warfare against the enemies of safety one of the most effective weapons is legislation

(Suggested by George B. Longstreet, Somerville, Mass.)

Harrisburg, Ill., Railway and Power Plant

By Thomas Wilson

SYNOPSIS—A 2000-kw. condensing turbine plant supplying current for an interurban line, for a number of mines and for lighting. A softener and purifier converts hard, muddy and corrosive water into excellent boiler feed at a cost of 1c. per 1000 gal.

On the middle fork of the Saline River (more commonly known as the Big Muddy), two miles from Harrisburg, Ill., the Southern Illinois Railway & Power Co. built its power plant. It has been in operation more than a year, supplying current at 1200 volts to a single-track interurban line running from Eldorado to Carrier Mills, a distance of 16 miles. The intervening stations are Wasson, Muddy, Harrisburg, Dorrisville and Ledford. The cars are run on hourly schedules, and in the morning and evening hours extra service is given to convey the miners to and from their work. Arrangements have been made with the Illinois Central railroad for interline freight service twice a day, and the coal for the plant is hauled over the company's line.

Three-phase 60-cycle current is generated at 2300 volts, and by motor-generator sets this is transformed into 1200-volt direct current for the railway. Current for power and lighting is stepped up to 33,000 volts through

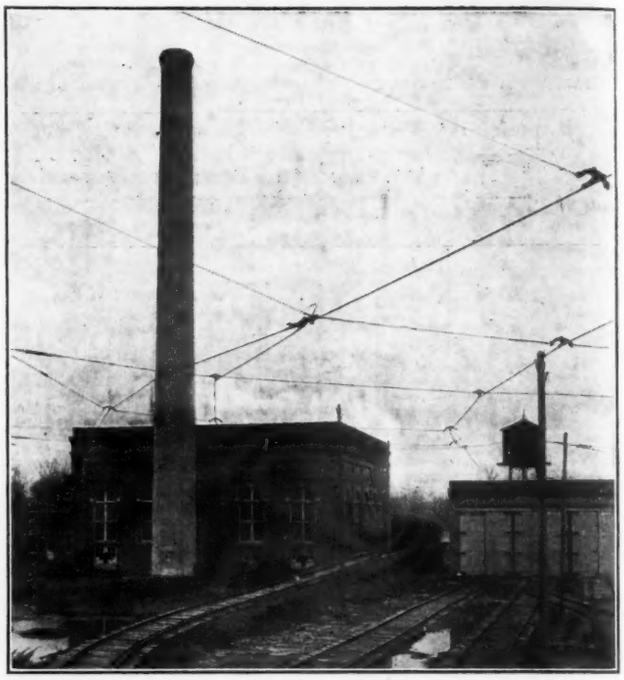


Fig. 1. Harrisburg Plant of Southern Illinois Ry. & Power Co.

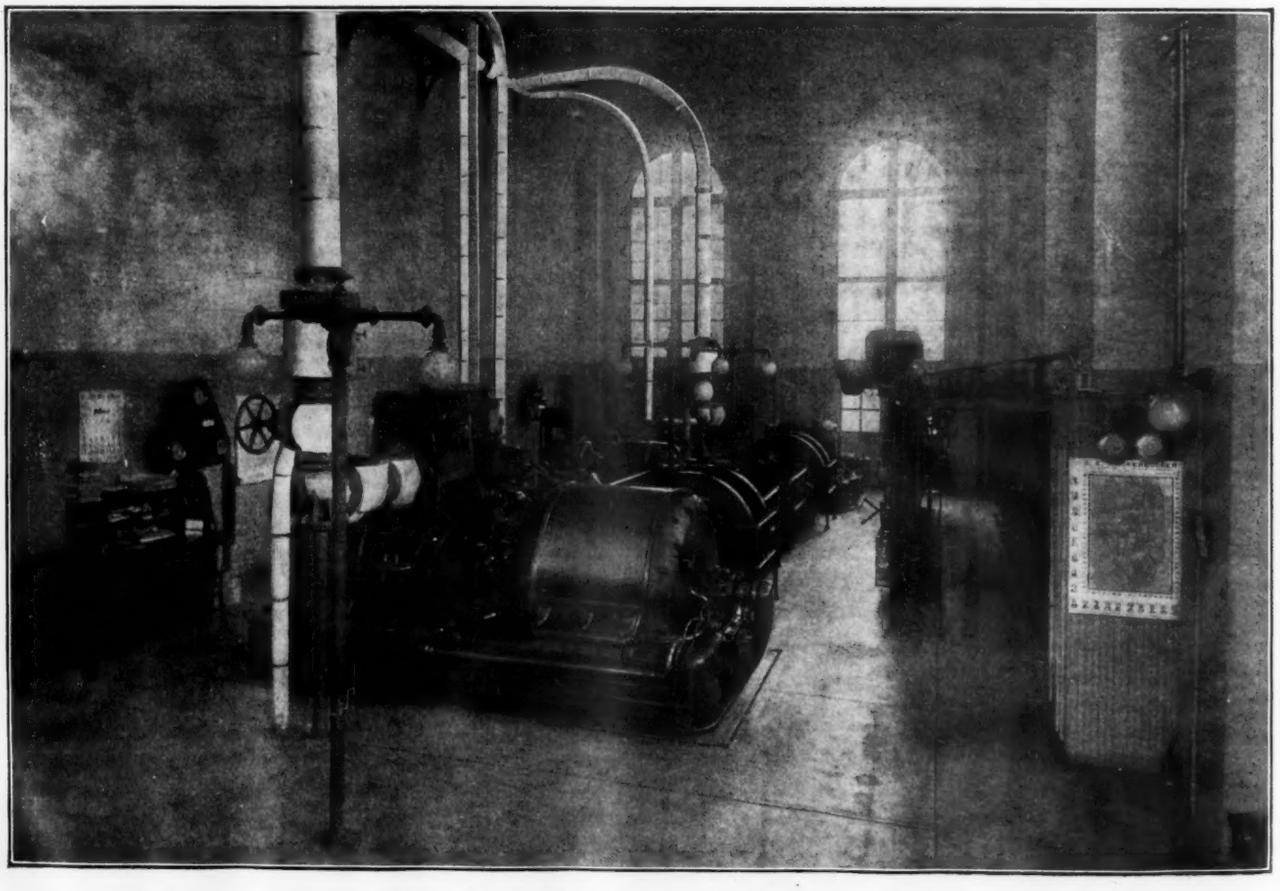


Fig. 2. View in Turbine Room

two banks of three single-phase water-cooled transformers connected in closed delta. At the receiving end it is stepped down to 2300 volts. The Wasson mines, which are electrically equipped, take service. They require direct current at 250 volts for cutting, hauling, etc., and this is obtained through a motor-generator set. Through

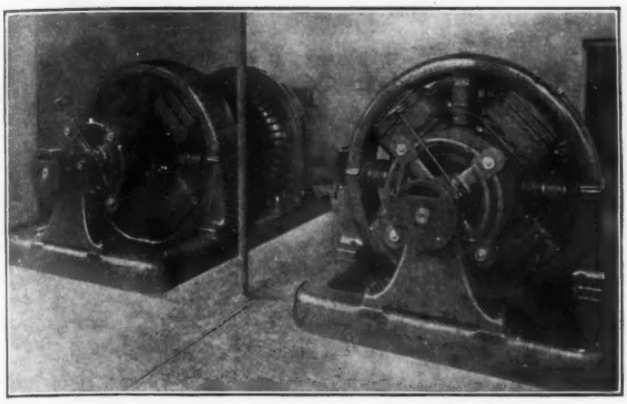


FIG. 3. MOTOR-GENERATORS SUPPLYING RAILWAY LOAD

three-phase, 60-cycle, 2300-volt generators at 3600 r.p.m. Condensers are of the surface type, each containing 3600 sq.ft. of surface, or 3.6 sq.ft. per kilowatt of generator rating, and served by a reciprocating dry-vacuum pump, a motor-driven centrifugal pump and a steam-condensate pump. Each circulating pump has a capacity of 3000 gal. per min. The suction of each connects to a 20-in. intake running west from the plant to a crib in the storage reservoir. The latter circles to form a U, so that the discharge from the condensers is received south of the plant at a distance of about one-quarter mile from the inlet. Spray nozzles arranged in clusters of five help to cool the water, and in any event a considerable period of time elapses before the water from the condensers gets back to the intake. The total lift for the pumps is 8 ft. The condensate is pumped to a 1600-hp. open heater, where its temperature is raised for boiler feeding.

It is evident that one generating unit will carry the load, operating at a small overload at the peaks and at a load factor averaging about 40 per cent. the remainder of the time.

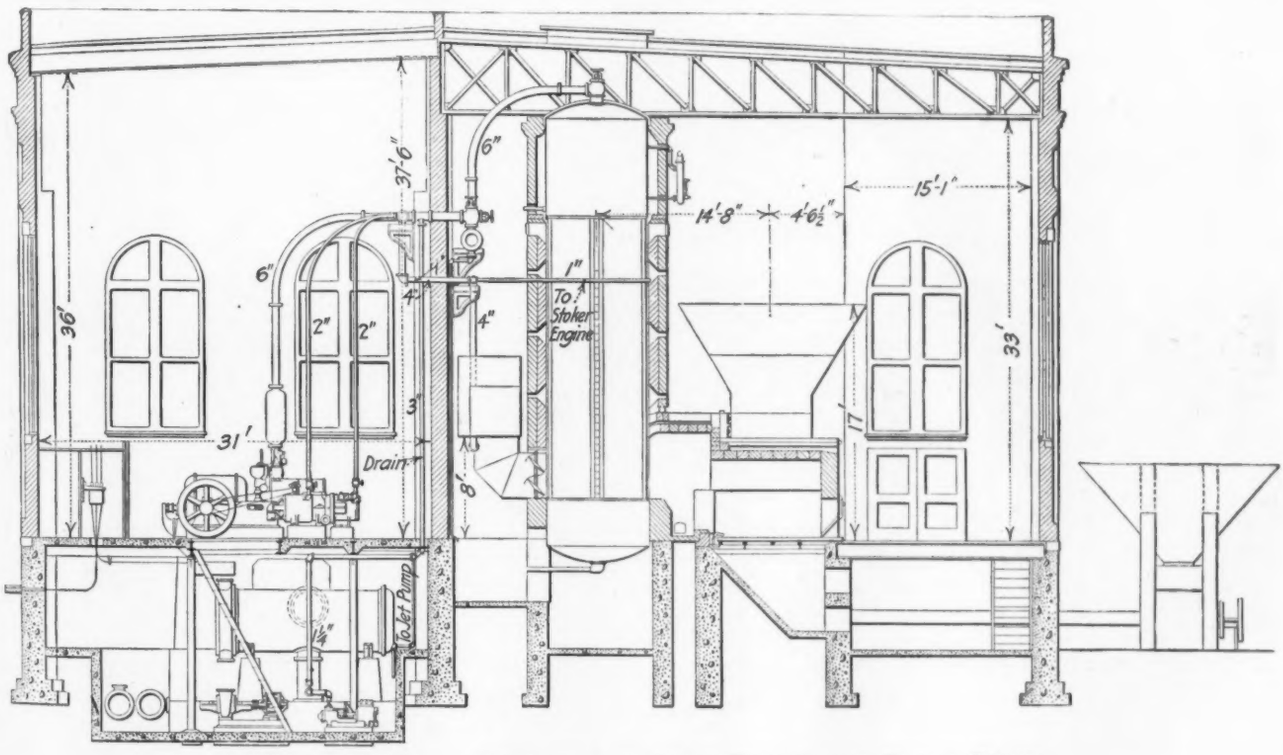


FIG. 4. SECTIONAL ELEVATION THROUGH ENGINE AND BOILER ROOMS

a distributing company light and power are furnished to Harrisburg. Carrier Mills is also lighted, and the transmission line has been extended recently to Marion.

AVERAGE LOAD

At present the load will run about 14,000 kw.-hr. a day. At the peak hours the load is about 1200 kw., but owing to the mine and traction loads, it is erratic. From midnight to 4:30 in the morning it will not exceed 500 kw., as the services are reduced to street lighting and mine ventilation.

GENERATING CAPACITY

The plant has a capacity of 2500 kv.-a., or, at 80 per cent. power factor, 2000 kw. This is divided into two units consisting of two-stage horizontal turbines driving

Excitation is furnished by two exciters, one driven by a motor and the other by a turbine, although the former is used for the most part. Usually, one of the 300-kw. motor-generator sets carries the railway load, but in the evening it is necessary to use both. The switchboard is fully equipped with modern instruments, hand-operated oil switches for the 2300-volt current and remote control for the high-tension service. Leads from the switchboard are conducted underground in vitrified tile conduit to the transformer building located near the plant.

BOILER PLANT

To serve the 2000 kw. in generating capacity there is 1600 hp. in boilers, a ratio of 5 to 4, or one boiler

horsepower per 1¼ kw. The boilers are of the vertical water-tube type, contain 3977 sq.ft. of heating surface, and are rated at 400 hp. Dry steam at 160 lb. pressure is supplied to the turbines. Stokers of the top-feed type serve the boilers. Each grate has a projected area of 64 sq.ft., which bears a ratio of 1 to 62 to the boiler

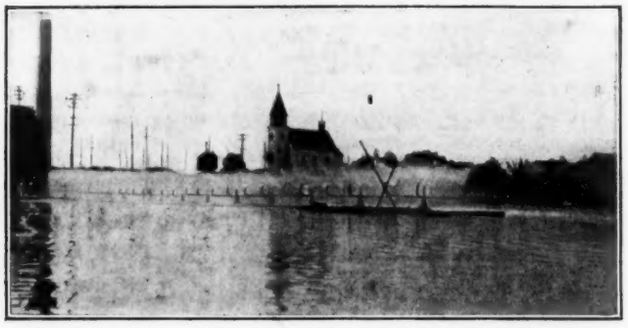


FIG. 5. SPRAY NOZZLES IN ACTION

heating surface. This is high when compared to the average 1 to 50 ratio, but as the grates are set at about 45 deg., the actual area is considerably greater than the 64 sq.ft. given above. The stack rises 155 ft. above the ground, or 135 ft. above the grate level. With a gas

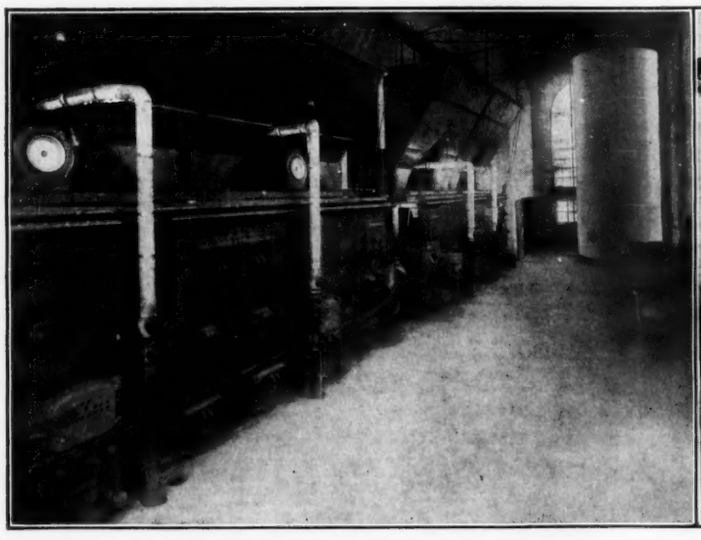


FIG. 6. THE BOILERS AND WATER PURIFIER

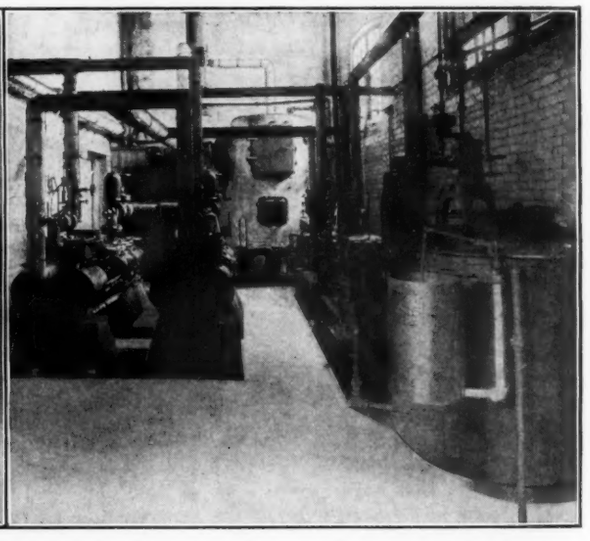


FIG. 7. PUMP ROOM, WITH CHEMICAL TANK OF PURIFIER IN FOREGROUND

temperature of 500 deg., the draft at the stack should be about 0.85 in. of water. Making the usual deductions for drop through breeching and setting, the draft over the fire for the boiler farthest from the stack should be about 0.25 in. and on the first boiler 0.35 in.

The stack, which is of concrete, is lined 50 ft. up. An internal diameter of 8 ft. gives a sectional area of 50 sq.ft. At each boiler the breeching is enlarged until at the stack it reaches a sectional area of 60 sq.ft., the width being 5 ft. and the height 12 ft. For each square foot of stack there are 1.2 sq.ft. of breeching, 5.1 sq.ft. of connected grate surface and 32 boiler horsepower.

COAL-HANDLING FACILITIES

The fuel burned is Saline County screenings. The thickness of the fuel bed is maintained at 3 to 5 in. on the inclined grates and 8 in. on the bottom. By forcing at the peaks one boiler could carry the load, but a second is carried under bank to be ready for emergencies. Under these conditions, combined with the low load factor on the generating units, the operating efficiency is low. From 5 to 6 lb. of coal is required per kilowatt-hour.

The coal is pulled over the company's track from Eldorado. It is dumped into a 30-ton hopper under the siding at the plant. From the hopper it passes through a crusher, which is operated only for lump coal, into a horizontal screw conveyor. A bucket elevator hoists it to the top of the boiler room and a second screw conveyor distributes it to 20-ton bunkers, one on top of each furnace. Ashes are wheeled from the pits to the elevator boot and are delivered to an ash screw at the top, which discharges them onto a temporary platform outside the plant, from which they may be wheeled into the empty coal cars. It is the intention to install a pneumatic system which will convey the ashes directly to the cars or a tank located beside the track.

UNUSABLE WATER TRANSFORMED INTO EXCELLENT BOILER FEED

One of the most serious problems the plant had to contend with was the water-supply. The water is taken from the Big Muddy River, which is well named, as the water retains its yellow, muddy color even in the reservoir, where it has a chance to settle. Besides containing a large amount of suspended matter, at certain seasons it is exceptionally hard and at all times is of a corrosive nature due to the acid drainage from the mines. A short period of operation showed that it would be neces-

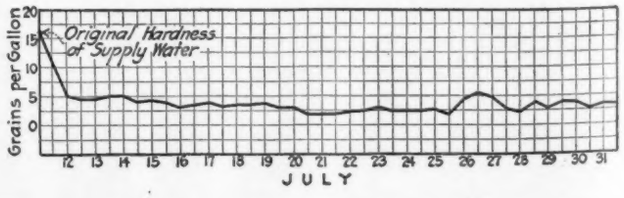


FIG. 8. CHART SHOWING HARDNESS OF WATER AFTER TREATMENT

sary to install a water softener and purifier, and this was done in the spring of 1914. The apparatus has a capacity of 2000 gal. per hr. The water from the reservoir is first pumped to a 25,000-gal. elevated tank, from which it flows to the top of the softening equipment by gravity. Here it is treated with 90 per cent. hydrated lime and 58-test soda ash, the proportions being governed by tests made twice a day. The chemicals neutralize the corrosive and scale-forming ingredients in the water and precipitate them in the form of insoluble matter. After the chemical treatment the water is allowed to settle and is then passed through a gravity quartz filter which is an integral part of the apparatus. Thence it flows by gravity into the feed-water heater and is pumped to the top drum of the boilers, although provision is also made to feed through the blowoff.

It might be stated that the river is one which varies greatly in its flow, depending upon the seasons of the year. For this reason the quality of the water varies widely, and the softener had to be adapted for accommodating the chemical charge to these variations in order to maintain a uniformly treated water. The chart, Fig. 8, shows the amount of hardening ingredients remaining in the treated water during a three-weeks' period in the month of July. The average hardness during the period is practically three grains. The following analyses, made at different periods, show the large variation in the quality of the river water.

	Mar. 4, 1914 Grains per Gal.	June 26, 1914 Grains per Gal.
Calcium carbonate	1.35	9.00
Calcium sulphate	1.97	...
Magnesium carbonate	...	...
Magnesium sulphate	3.29	9.38
Silica	5.30	...
Iron and aluminum oxides	0.75	...
Suspended matter	Undetermined	1.21
Total incrusting solids	12.66	19.59
Sodium sulphate	0.87	...
Sodium chloride	1.60	14.63
Total nonincrusting solids	2.47	14.63
Total solids	15.13	34.22

The following is an average analysis of water delivered during the past summer:

INCRUSTING SOLIDS

	Grains per Gal.
Calcium carbonate	2.16
Magnesium hydrate	1.40
Silica	0.06
Total incrusting solids	3.56

NONINCRUSTING SOLIDS

Sodium sulphate	12.06
Sodium chloride	14.32
Total nonincrusting solids	26.38
Total solids	29.94

The cost for treating the water has averaged about 1c. per 1000 gal. It varies directly with the hardening ingredients in the water, but runs from 1½c. per 1000 gal., which is the maximum, to nothing, as the supply at times contains such a large amount of rain water that it practically has no hardness. During these periods the chemical treatment is eliminated and the water is simply passed through the filter.

In the words of the chief engineer, E. H. Clark, the feed water is now ideal. The condensate from the condensers is returned to the heater and the 15 to 20 per cent. of makeup is the treated water. When the purifier was installed the boilers were thoroughly cleaned and the scale removed. Since then they have been opened up every 30 to 45 days, and washed out. During the nine months the purifier has been in service, there has been practically no scale and no evidence of corrosion.

The W. H. Schott Co., of Chicago, designed the plant and had charge of its erection, but the engineering is now under the direction of C. J. Davidson, of the firm of Woodmansee & Davidson, consulting engineers, of the same city. Under their direction the water softener and spraying nozzles were installed. They report a bright outlook for the plant. As previously stated, Marion has just been added to the list of towns taking service, and other prospects are in view which will increase the load and better the operating efficiency of the plant.

PRINCIPAL EQUIPMENT OF SOUTHERN ILLINOIS RAILWAY & POWER CO.'S PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Vertical water-tube	400 hp.	Generate steam	160-lb. pressure, natural draft, stokers	Wickes Boiler Co.
4	Stokers	Top-feed	Projected area, 64 sq.ft.	Serve boilers	Draft over fire 0.25 to 0.35 in.	Murphy Iron Works
1	Stack	Concrete	155 ft. high, 8 ft. diam.	Natural draft for boilers		General Concrete Construction Co.
1	Coal conveyor	Screw-and-bucket	20 tons per hr.	Transfer coal from car to bunker	Driven by 20-hp. induction motor	A. Lucas & Sons
1	Coal crusher		20 tons per hr.	Crush lump coal	Driven by 20-hp. induction motor	A. Lucas & Sons
1	Water softener	Cold process	2000 gal. per hr.	Soften boiler feed		Wm. Graver Tank Works
1	Heater	Open	1600 hp.	Heat boiler feed water	Exhaust from auxiliaries	Platt Iron Works Co.
2	Pumps	Duplex	10x6x12-in.	Feed boilers	160 lb. steam	Platt Iron Works Co.
2	Pumps	Duplex	6x7x10-in.	Water from reservoir to tank	160 lb. steam	Platt Iron Works Co.
1	Air compressor	Locomotive	9½x9½x10-in.	Blowing flues, etc.	160 lb. steam	Westinghouse Air Brake Co.
2	Turbines	2-stage, horizontal, Curtis	1000-kw.	Main units	Drive at 3600 r.p.m., three-phase, 60-cycle, 2300-volt generators	General Electric Co.
2	Condensers	Surface	3600 sq.ft.	Serve main units		Platt Iron Works Co.
2	Pumps	Dry-vacuum	10x18x18-in.	Serve condensers	160 lb. steam	Platt Iron Works Co.
2	Pumps	Centrifugal	3000 gal. per min.	Condenser circ. water	Driven 1250 r.p.m. by 50-hp. ind. motors	Platt Iron Works Co.
2	Pumps	Duplex	7x5x6-in.	Condensate pumps	160-lb. steam	Platt Iron Works Co.
75	Spray nozzles		2-in. base, ¾-in. nozzle	Cool condenser water		Spray Engineering Co.
1	Exciter	Turbine-driven	35-kw.	Excitation for main units	125-volt, 3600 r.p.m.	General Electric Co.
1	Exciter	Motor-driven	50-kw.	Excitation for main units	125-volt, 1200 r.p.m., motor 75 hp., ind., 2300-volt	General Electric Co.
2	Motor-generator sets	Railway	300-kw.	Railway service	2300-volt synchronous motor, 430 hp., 720 r.p.m., 1200-volt, constant-current generator.	General Electric Co.

The Advantages of Small, High-Velocity Steam Piping are: Lower first cost for pipe, valves and covering, etc., less erecting and maintenance cost; less weight; less radiation loss; less chance for water to accumulate and less difficulty with valves of smaller size.

To Increase Industrial Prosperity this country needs to export finished rather than crude products and to import raw materials rather than manufactures. Betterment of industrial conditions can come best through expansion of manufacturing. The increase of the element of labor in the product exported will mean that we are not bartering away our heritage of natural resources, but rather that we are using these resources as a basis simply for the expenditure of labor, which renews itself—George Otis Smith, Director, United States Geological Survey.

Interior Wiring for Lighting and Power Service--IV

By A. L. Cook

SYNOPSIS—The previous articles of the series covered the layout and wiring calculations for lighting systems; the present and succeeding installments cover power circuits, including location of motors and control devices, determination of load, voltage drop and wiring calculations.

It is beyond the scope of this article to discuss the types of motors best suited for various industrial conditions, but the location of motors and the choice of control devices will be considered before taking up the wiring. The location of the motor will be, to a large extent, fixed by that of the driven machine. If there is a choice, however, it should be placed where it can be easily reached for inspection, and also where it will be protected, as far as the surroundings permit, from moisture, dust and accumulations of dirt. It is desirable to avoid where possible the use of entirely inclosed motors because of their greater cost. Control devices also should be selected with regard to where they are to be used and the class of labor which is to operate them. They should be placed in the position most convenient for the operation of the motor and should always include a switch located in sight of the motor, by means of which all wires running to the motor or control device can be disconnected from the supply. This is necessary to facilitate repairs and is a safeguard against operation by unauthorized persons. If the motors are supplied from near-by panel-boards, these switches can be placed on the panels.

The systems of distribution for power include two-wire alternating or direct current, and three-phase or two-phase alternating current. The standard voltages for direct-current motor service have already been specified. A voltage of 115 should be used only where the motors are small and the feeders short. The best voltage for usual conditions is 230, as this gives reasonably small conductors, even for long runs. One advantage of this voltage is that the supply can easily be made three-wire for lighting and two-wire (230 volts) for the motors. A voltage of 550 should be used only where the feeders are very long and the motors large. The panel-boards and control devices will be much larger than for the other voltages, and the cost of maintenance of the system under usual factory conditions will be greater. There is also greater danger of injury to the workmen than with lower voltages. This high voltage is not at all adapted for power supply in an office building and is seldom used for that purpose.

A two-wire alternating-current system (single-phase system) is adapted only to supplying motors up to about 15 hp. With alternating current, either the three-phase or the two-phase system is ordinarily used. The former is best adapted for the usual power supply in factories, the two-phase system being used principally by central stations, where the lighting and motor loads are carried on the same distributing system; in which case the two-phase system is easier to balance than the three-phase. It is possible, however, to operate either system satisfactorily in this way. For an isolated plant, however, the three-phase system is preferable; the lighting load being taken from one or more phases, depending on its relative importance compared with the power load. The choice between 25 and 60 cycles is influenced by the fact that the latter is better for lighting and the cost of the motors is somewhat less. There is also the advantage of a greater number of available speeds in 60-cycle motors for the range usually needed.

Choice of Motors

Alternating-current motors have definite speeds, fixed by the frequency and depending upon the number of poles, whereas direct-current motors have greater flexibility in this respect. The available no-load speeds for alternating-current motors for the usual range are given in Table 10. The highest speed is for the two-pole motor, and the speed can be made as low as required by providing a suitable number of poles. It will be seen by reference to this table that for 25 cycles motors can be built for only three speeds between 500 r.p.m. and the maximum; whereas for 60 cycles there are seven speeds. All of these speeds cannot be obtained from the same motor, which, on the contrary, must be built for a particular speed, and only by special design can it be run at more than one of these speeds; even then the number of available speeds is limited to two.

The alternating-current system is generally better suited for factory power supply than the direct-current, because of the greater reliability and ruggedness of the alternating-current motor. The standard alternating voltages available for general use with either three-phase

TABLE 10—AVAILABLE SPEEDS FOR ALTERNATING-CURRENT MOTORS

Number of Poles	No-Load Speed, R.p.m. 60 Cycles	25 Cycles
2	3600	1500
4	1800	750
6	1200	500
8	900	375
10	720	300
12	600	250
14	514	214

or two-phase systems are 110, 220, 440 or 550 volts, and for large motors 2200 volts. The ease with which the voltage may be changed to suit conditions allows great flexibility in the choice of a voltage for the motors. Either 220 or 440 volts is commonly used, the lower voltage being preferable for moderate-sized installations, particularly where the supervision may be in relatively unskilled hands. The danger of workmen receiving fatal shocks is greater with alternating than with direct current, and 440 or 550 volts presents a real hazard in this respect; shock from 220 volts is seldom fatal. In establishments of considerable size, particularly with large motors, the great saving in feeder size with 440 or 550 volts results in their frequent use.

More complete protection is permissible with alternating than with direct current, so that with careful planning of the control devices and first-class wiring, these higher-voltage systems can be made fairly safe. Sometimes 1100 or 2200 volts are used for alternating-current motor drive, but as such a high voltage is adapted only for large motors and requires special methods of installation of the

wiring and control system to make it safe, these will not be considered in this article.

The common types of direct-current motors are the shunt motor, which is practically constant-speed, and the series motor, which gives variable speed. While the former is called a constant-speed machine, since the speed is practically constant from no load to full load, the speed can be adjusted through a wide range by changing the resistance in either the field or the armature circuit, the former method being preferable. The shunt motor is adapted for any constant-speed service, such as driving machine tools, woodworking machinery, fans, and the like, while the series motor is best adapted for driving cranes, hoists and similar devices. For some purposes a compound motor, which combines the characteristics of the series and shunt, is best; the principal applications of this type being found in the driving of elevators, punch-presses, planers, etc.

The usual type of alternating-current motor is the induction motor, which may be of the squirrel-cage or the wound-rotor type. The former is the most rugged and the simplest kind of motor made, and is cheaper and more satisfactory for general use than the wound-rotor type. A disadvantage is that it cannot start under heavy load without taking a large current from the line, but where the starting load is less than full load and a constant speed is required, the squirrel-cage motor should be used. If the driven machine requires a large starting torque, as for example, a compressor starting under full pressure, or if the speed must be adjusted, then the wound-rotor type must be used. Sometimes it is desirable to use this type of motor for constant-speed service when the size of the motor is large compared with the capacity of the generator supplying the load, because of the great drop in voltage caused by starting a large motor.

The full-load current required by a motor is always marked on the nameplate, but it is frequently necessary to lay out the wiring before the motors have been received. To assist in estimating the load, Tables 11, 12 and 13 have been prepared. The full-load currents given are for

TABLE 11—CURRENT AND SIZE OF WIRE FOR DIRECT-CURRENT MOTORS

Horsepower	Amperes, Full Load 115 V.	230 V.	550 V.	Size of Wire*—Rubber Insulation—115 V.	230 V.	550 V.	Size of Wire*—Other Insulation—115 V.	230 V.	550 V.
0.5	5	2.5	1.1	14	14	14	14	14	14
1	8.8	4.4	1.8	14	14	14	14	14	14
2	16	8	3.4	10	12	14	14	14	14
3	24	12	5	8	12	14	8	14	14
5	40	20	8.4	5	8	14	6	10	14
7.5	58	29	12.1	3	6	12	5	8	14
10	76	38	15.9	1	5	10	3	6	12
15	112	56	23.4	00	3	8	1	5	10
20	146	73	30.5	0000	1	6	0	3	8
25	182	91	38.1	250,000	0	6	000	2	8
30	216	108	45.2	350,000	00	4	000	1	6
35	252	126	52.6	400,000	000	4	0000	0	6
40	288	144	60.2	500,000	0000	3	300,000	0	5
50	356	178	74.4	600,000	250,000	1	350,000	000	3
60	428	214	89.5	800,000	350,000	0	500,000	000	2
75	532	266	111	1,100,000	450,000	00	600,000	250,000	1
100	710	355	148	1,700,000	600,000	0000	900,000	350,000	0
125	886	443	185	two 850,000	850,000	300,000	1,200,000	500,000	00
150	1076	535	224	two 1,100,000	1,100,000	400,000	1,600,000	700,000	0000

*Allows at least 25 per cent. overload.

direct-current motors and for the usual type of alternating-current induction motors. For the direct-current motors, the "National Electric Code" requires that the size of wires shall be sufficient to carry at least a 25-per cent. overload and the usual motor for continuous service is designed to carry a 25-per cent. overload for two hours. The sizes of wire specified in Table 11 are such that the motor can carry from 25 to 30 per cent. overload without exceeding the current rating of the wire in accordance with the "Code" rules. To find the current and size of wire for a motor not given in the table, find the amperes per horsepower for the next smallest motor, and then multiply by the horsepower of the given motor. For example, to find the current for a 65-hp. 550-volt direct-current motor, we find that the current per horsepower is $\frac{89.5}{60} =$ 1.49 amp. The full-load current for a 65-hp. motor is then $149 \times 65 = 97$ amp. Allowing 25 per cent. overload, the current would be 121 amp., and if rubber-covered wire is used the size would be No. 0.

TABLE 12—CURRENT AND SIZE OF WIRE FOR THREE-PHASE INDUCTION MOTORS, SQUIRREL-CAGE TYPE

Horsepower	Amperes, Full Load 110 V.	220 V.	440 V.	550 V.	Size of Wire, Rubber or Other Insulation 110 V.	220 V.	440 V.	550 V.
*0.5	3.6	1.8	0.9	0.7	14	14	14	14
*1.0	6.4	3.2	1.6	1.3	12	14	14	14
*2.0	11.6	5.8	2.9	2.3	8	12	14	14
*3.0	16.4	8.2	4.1	3.3	6	8	14	14
5.0	26.8	13.4	6.7	5.4	5	8	12	12
7.5	39.2	19.6	9.8	7.9	21	6	10	12
10.0	53.2	26.6	13.3	10.7	0	5	8	8
15.0	77.0	38.6	19.3	15.5	00	2	6	8
20.0	109.0	54.6	27.3	21.8	0000	0	5	6
25.0	125.0	62.6	31.3	25.1	300,000	0	4	5
35.0	...	85.6	42.8	34.3	....	000	2	3
50.0	...	122.0	61.0	48.6	....	250,000	0	1
75.0	...	179.0	89.0	72.0	....	450,000	000	0
100.0	...	237.0	118.0	95.0	....	600,000	250,000	000
150.0	...	353.0	176.0	141.0	....	1,100,000	400,000	300,000
200.0	...	451.0	226.0	181.0	....	(2) 600,000	600,000	450,000
250.0	...	560.0	280.0	224.0	....	(2) 800,000	800,000	600,000
300.0	...	670.0	335.0	268.0	....	(2) 1,000,000	1,000,000	800,000

*These motors are thrown directly on the line; all others are provided with auto-starters set to give a starting torque equal to full-load running torque.

The allowance mentioned for overload would be sufficient in the majority of cases; but if the motor is subject to heavy momentary overloads, as for example in the case of a planer drive, a larger overload should be allowed. There is a disadvantage in fusing the motor too high, as it is then not protected against continuous overload which might burn out the motor. For alternating-current motors also, the "Code" requires that the wire shall be sufficient to allow at least 25 per cent. overload. Tables 12 and 13 give data for three-phase and two-phase induction motors, the full-load current values being for modern, high-efficiency motors. These values apply more particularly to the squirrel-cage type; for wound-rotor type of motor the full-load currents would be slightly greater. Squirrel-cage induction motors take very large currents from the line when starting, averaging about 2.9 times the full-load value with a torque equal to full-load running torque. To obtain this starting torque, about 85 per cent. of full-load voltage is applied to the motor. Usually, the load driven by a squirrel-cage motor is such that a voltage of 65 per cent. can be used, and then the starting current will be only about 2.2 times full-load current. A wound-rotor type of induction motor, starting under full load, takes about 25 per cent. more than the full-load current when running.

Because of the heavy starting current required for squirrel-cage induction motors, the rules allow the leads to be selected in accordance with column B of Table 7 (see page 642, May 11 issue) even when rubber-covered wire is used. The sizes specified in Tables 12 and 13 are chosen on this basis. For wires with other insulation the same allowance is not made; that is, according to the "Code," the wire must be chosen in accordance with col-

umn B also. However, the inspectors will often allow induction-motor wires when exposed to be fused somewhat higher than the values given in column B. It is apparent that the wires will be adequately protected from injury when fused in accordance with these rules, but the motor will not be properly protected against continuous overloads, which would not cause the fuses to blow, but still would be larger than the motor could safely stand for any length of time. It is customary, therefore, to provide "running fuses" which are not in circuit during starting. The ordinary induction motor is rated to stand a 25-per cent. overload for two hours, but can carry greater loads for short periods. Therefore, the running fuses should have a rating about 50 per cent. greater than the full-load current of the motors.

The rules given for determining the proper size of wire and the fusing of motors apply to motors intended for continuous service, which are designed to carry their rated load continuously or to carry a 25-per cent. overload for two hours. There are certain other kinds of service, such as cranes and elevators, where the load is intermittent and the motor is required to carry heavy momentary loads. The sizes of fuses and wires for this service are chosen somewhat differently, the motors being rated at the load which they will carry for 30 min. without exceeding a safe temperature. Direct-current motors for intermittent service will, however, carry a 50-per cent. overload for short periods without injury and will carry a 100-per cent. overload momentarily without injurious sparking. Alternating-current motors are also rated on a 30-min. basis, and since they have no commutator, will stand for short periods large overloads, amounting to 2 or 2½ times full-load current. Direct-current motors for intermittent service should be provided with fuses allowing at least 50 per cent. overload, and the branch circuits for the motors must therefore be sufficient to carry this current. If rubber-insulated wire is used, column A of Table 7 should be used; for other insulations column B should be employed. In the case of alternating-current motors, the "Code" specifies definitely the current rating for the branch circuits; the values given are as follows:

Service	Percentage of Current Rating of Motor
Operating valves, raising or lowering rolls, tool heads, etc.	200
Hoists, rolls, ore- and coal-handling machines	180
Freight elevators, shop cranes	160
Passenger elevators	140
Rolling tables, pumps	120

This applies to varying-speed alternating-current motors; that is, where the speed changes with varying loads, as in the series direct-current motor, the current referred to being rated for the 30-min. load rating, as previously mentioned. The size of wire must be selected by using either column A or B of Table 7, depending upon the insulation.

In general each feeder will supply a number of motors and in order to calculate its size the probable maximum current to be carried by the feeder must be determined. For usual factory conditions this would be considerably less than the sum of the full-load currents of the motors connected to the feeder. It would seldom occur that all the motors would be carrying full load at the same time. Consequently, a load factor must be assumed, the term load factor meaning the ratio of the maximum to the total connected load. This may vary from 40 to 80 per cent., depending upon the nature of the work and the number and size of motors on the feeder. Where there is a large number of small motors, this factor would be less than where there are a few large motors on the system. For ordinary factory conditions, in the absence of better information, the load factor for the feeders may be taken as 75 per cent. of the rated load of the motors. With alternating current the size of wire should be checked by assuming the largest motor starting and all the others running, allowing 75 per cent. of the full-load current for these motors.

TABLE 13—CURRENT AND SIZE OF WIRE FOR TWO-PHASE INDUCTION MOTORS, SQUIRREL-CAGE TYPE

Horse-power	Amperes, Full Load† 110 V.	220 V.	440 V.	550 V.	Size of Wire, Rubber or Other Insulation 110 V.	220 V.	440 V.	550 V.
*0.5	3.2	1.6	0.8	0.6	14	14	14	14
*1.0	5.6	2.8	1.4	1.1	14	14	14	14
*2.0	10.0	5.0	2.5	2.0	8	14	14	14
*3.0	14.4	7.2	3.6	2.9	6	10	14	14
5.0	23.2	11.6	5.8	4.7	6	8	12	14
7.5	34.0	17.0	8.5	6.8	3	8	12	14
10.0	46.0	23.0	11.5	9.2	1	6	8	10
15.0	66.8	33.4	16.7	13.4	0	3	8	8
20.0	94.4	47.2	23.6	18.9	000	1	6	6
25.0	108.4	54.2	27.1	21.7	0000	1	5	6
35.0	...	74.2	37.1	29.7	....	00	2	4
50.0	...	105.0	52.6	42.1	....	0000	0	2
75.0	...	155.0	77.3	61.9	....	350,000	00	0
100.0	...	205.0	103.0	82.0	....	500,000	0000	000
150.0	...	306.0	153.0	123.0	....	900,000	350,000	300,000
200.0	...	390.0	195.0	156.0	....	(2) 500,000	500,000	400,000
250.0	...	484.0	242.0	194.0	....	(2) 700,000	700,000	500,000
300.0	...	580.0	290.0	232.0	....	(2) 800,000	800,000	600,000

*These motors are thrown directly on the line; all others are provided with auto-starters set to give a starting torque equal to full-load running torque.

†Values of current are for a two-phase, four-wire system; if three wires are used, current in common wire would be 1.42 times value given.

The allowable voltage drop for power circuits can be greater than for lighting circuits, but should not be too large, particularly with induction motors, as they do not operate satisfactorily at voltages greatly below normal. A total of 5 per cent. drop, figured from the motor to the service point or the power-house switchboard, is satisfactory and does not require excessive feeder sizes. This voltage drop should be divided about as follows: Individual motor circuits, 1.75 per cent.; feeders and subfeeders, 3.25 per cent.; total, 5 per cent.

Direct-current motor circuits can be calculated by means of the wiring chart already described (see page 667 May 18 issue). Alternating-current circuits cannot be calculated as easily. This is because of the power factor of the motor circuits, which is generally about 0.80. The effect of this power factor is to make the drop greater than if it were 1.00, as in the case of lighting loads. The extent to which the drop is thus increased depends upon the spacing between wires, the effect being least when the wires are in one conduit and increasing very rapidly when they are separated and run on insulators. When all the wires of a circuit are run in the same conduit the drop is practically the same as for direct current, for wires not greater than No. 0 for 60-cycle circuits and not larger than 300,000 circ.mils for 25 cycles. The wiring chart which was used in lighting calculations can therefore be used for such cases. For larger wires run in conduit and for all wires separated a considerable distance, as in exposed work, the drop must be calculated by other means. The simplest method is to determine the drop in the usual manner, by means of the direct-current chart already explained, and then to determine the additional drop which would be caused by the inductive effect. A method for doing this has been developed by

C. F. Scott and C. P. Fowler and was published in the April, 1907, issue of *The Electric Journal.*

The drop due to inductance depends upon the ratio of reactance to resistance and also upon the power factor. The reactance depends upon the frequency and upon the spacing between wires. We require, then, a table giving this ratio for the particular spacing of the wires and the proper frequency and also a table giving the drop factor corresponding to various values of this ratio. Tables 14 and 15 give these quantities.

An example in the use of these tables will assist in understanding the method employed. Assume a No. 00 wire carrying a single-phase alternating current of 50 amp. a distance of 150 ft. at a frequency of 60 cycles. The drop, if direct current were used, is found by the chart (page 667, May 18 issue) to be 1.2 volts. Assuming the wires are all in the same conduit, it will be seen from Table 14 that the ratio of reactance to resistance is 0.54. Assume that the load consists of incandescent lamps, so that the power factor may be taken as 1.0. Then the drop factor is found from Table 15 to be 1.004. That is, the direct-current drop of 1.2 volts must be multiplied by 1.004, which gives 1.205 volts. Hence the alternating-current drop under these conditions is practically the same as the direct-current drop. If the wires are 6 in. apart the ratio would become 1.04, the drop factor would be 1.044 and the alternating-current drop would be 1.25 volts. If the power factor is 0.8, the drop factor would be 1.42 and the alternating-current drop would be 1.70 volts. It will be seen that for a power factor of 1.0 the alternating-current drop is practically equal to the direct-current drop for ratios up to 0.7, being only 1 per cent. higher for 0.6. For lower power factors, however, the alternating-current drop is, in general, different from, and may be less than, that for direct current. Therefore, it is necessary to estimate this in each case. Table 16 gives the usual values of the power factor for various kinds of loads. The values for induction motors assume that all the motors on a feeder would not be carrying full load at the same time. The power factor of induction motors when carrying full load is in general greater than the values herewith given.

The values refer to the sizes of the individual motors on the feeder. That is, if a feeder carried one 15- and four 10-hp. motors the total connected motor load would be 55 hp., but the power factor on the feeder should be taken as 0.80. By examining Tables 14 and 15 it will be noted that the alternating-current drop increases very rapidly as the size of wire increases. As a rule, wires larger than 300,000 circ.mils should be avoided, except

TABLE 14—RATIO OF REACTANCE TO RESISTANCE

Size of Wire	Ratios for Distance between Wires of— In Conduit	2½ In.	4 In.	5 In.	6 In.	8 In.	12 In.
			60 Cycles				
10	0.05	0.09	0.10	0.11	0.11	0.12	0.13
8	0.08	0.13	0.15	0.16	0.17	0.18	0.19
6	0.12	0.21	0.23	0.24	0.26	0.27	0.29
5	0.14	0.25	0.28	0.30	0.31	0.33	0.36
4	0.15	0.30	0.34	0.36	0.38	0.41	0.44
3	0.22	0.37	0.42	0.45	0.47	0.50	0.54
2	0.26	0.45	0.52	0.55	0.57	0.62	0.67
1	0.32	0.54	0.62	0.67	0.70	0.75	0.82
0	0.38	0.66	0.77	0.82	0.86	0.92	1.01
00	0.54	0.80	0.93	0.99	1.04	1.13	1.25
000	0.64	0.97	1.14	1.21	1.28	1.38	1.53
0000	0.76	1.17	1.38	1.48	1.56	1.70	1.87
300,000	1.01	1.54	1.84	1.98	2.10	2.28	2.52
400,000	1.49	1.93	2.33	2.52	2.67	2.92	3.26
500,000	1.75	2.30	2.80	3.03	3.22	3.54	...
600,000	1.85	2.52	3.10	3.40	3.63	...	...
700,000	2.06	2.84	3.54	...	...	...	...
800,000	2.49	3.12	...	...	...	...	...
900,000	2.69	3.39	...	...	...	...	...
1,000,000	2.89	3.66	...	...	...	...	...
			40 Cycles				
10	0.03	0.06	0.07	0.07	0.07	0.08	0.09
8	0.05	0.09	0.10	0.11	0.11	0.12	0.13
6	0.08	0.14	0.15	0.16	0.17	0.18	0.19
5	0.09	0.17	0.19	0.20	0.21	0.22	0.24
4	0.10	0.20	0.23	0.24	0.25	0.27	0.29
3	0.15	0.25	0.28	0.30	0.31	0.33	0.36
2	0.17	0.30	0.35	0.37	0.38	0.41	0.45
1	0.21	0.36	0.41	0.45	0.47	0.50	0.55
0	0.25	0.44	0.51	0.55	0.57	0.61	0.67
00	0.36	0.53	0.62	0.66	0.69	0.75	0 83
000	0.43	0.65	0.76	0.81	0.85	0.92	1 02
0000	0.51	0.78	0.92	0.99	1.04	1.13	1.25
300,000	0.67	1.02	1.22	1.32	1.40	1.52	1.67
400,000	1.00	1.28	1.55	1.68	1.77	1.95	2.17
500,000	1.17	1.53	1.87	2.02	2.14	2.36	2.43
600,000	1.23	1.68	2.07	2.27	2.42	2.67	3.02
700,000	1.38	1.90	2.36	2.58	2.76	3.05	3.45
800,000	1.67	2.08	2.63	2.87	3.08	3.40	...
900,000	1.80	2.27	2.87	3.15	3.38	...	...
1,000,000	1.93	2.45	3.08	3.40	3.67	...	...
			25 Cycles				
10	0.02	0.04	0.04	0.05	0.05	0.05	0.05
8	0.03	0.05	0.06	0.07	0.07	0.08	0.08
6	0.05	0.09	0.10	0.10	0.11	0.11	0.12
5	0.06	0.10	0.12	0.13	0.13	0.14	0.15
4	0.06	0.12	0.14	0.15	0.16	0.17	0.18
3	0.09	0.15	0.18	0.19	0.20	0.21	0.23
2	0.11	0.19	0.22	0.23	0.24	0.26	0.28
1	0.14	0.23	0.26	0.28	0.29	0.31	0.34
0	0.16	0.28	0.32	0.34	0.36	0.38	0.42
00	0.23	0.33	0.39	0.41	0.43	0.47	0.52
000	0.27	0.40	0.48	0.51	0.53	0.58	0.64
0000	0.32	0.49	0.58	0.62	0.65	0.71	0.78
300,000	0.42	0.64	0.77	0.83	0.88	0.95	1.05
400,000	0.62	0.81	0.97	1.05	1.11	1.24	1.36
500,000	0.73	0.96	1.17	1.26	1.34	1.48	1.65
600,000	0.77	1.05	1.29	1.42	1.51	1.67	1.88
700,000	0.86	1.18	1.47	1.61	1.72	1.91	2.15
800,000	1.06	1.30	1.64	1.79	1.92	2.12	2.31
900,000	1.12	1.42	1.79	1.96	2.11	2.34	2.49
1,000,000	1.29	1.53	1.92	2.12	2.29	2.54	...

TABLE 15—DROP FACTORS*

Ratio of Reactance to Resistance	Drop Factors for Power Factors of— 1.00	0.95	0.90	0.85	0.80	0.70	0.60	0.40
0.1	1.00	1.00	1.00	0.94	0.88	0.80	0.70	0.60
0.2	1.00	1.01	1.01	0.98	0.92	0.86	0.82	0.67
0.3	1.00	1.05	1.05	1.02	0.99	0.93	0.89	0.74
0.4	1.00	1.08	1.10	1.08	1.04	1.00	0.93	0.82
0.5	1.00	1.11	1.14	1.13	1.10	1.07	1.01	0.92
0.6	1.01	1.15	1.18	1.19	1.15	1.14	1.09	1.01
0.7	1.02	1.18	1.23	1.24	1.21	1.20	1.17	1.11
0.8	1.02	1.21	1.28	1.29	1.28	1.27	1.24	1.20
0.9	1.03	1.25	1.33	1.34	1.34	1.35	1.32	1.29
1.0	1.04	1.28	1.37	1.39	1.40	1.41	1.39	1.38
1.1	1.05	1.32	1.41	1.44	1.45	1.48	1.47	1.46
1.2	1.06	1.35	1.46	1.50	1.51	1.55	1.54	1.55
1.3	1.07	1.39	1.51	1.55	1.57	1.62	1.63	1.64
1.4	1.08	1.43	1.55	1.61	1.64	1.70	1.71	1.72
1.5	1.10	1.47	1.60	1.67	1.70	1.77	1.80	1.81
1.6	1.10	1.51	1.65	1.74	1.77	1.85	1.87	1.90
1.7	1.13	1.55	1.70	1.79	1.84	1.92	1.95	1.99
1.8	1.15	1.59	1.76	1.85	1.91	1.99	2.04	2.08
1.9	1.17	1.63	1.82	1.91	1.98	2.06	2.11	2.16
2.0	1.18	1.68	1.87	1.96	2.04	2.14	2.19	2.25
2.1	1.20	1.72	1.92	2.03	2.10	2.21	2.28	2.35
2.2	1.22	1.77	1.98	2.09	2.17	2.29	2.37	2.45
2.3	1.23	1.82	2.03	2.15	2.23	2.37	2.45	2.53
2.4	1.25	1.87	2.09	2.22	2.30	2.44	2.53	2.62
2.5	1.27	1.91	2.14	2.28	2.37	2.52	2.60	2.71
2.6	1.30	1.95	2.20	2.34	2.44	2.60	2.67	2.80
2.7	1.32	1.99	2.26	2.41	2.51	2.68	2.74	2.98
2.8	1.35	2.05	2.32	2.47	2.57	2.76	2.82	3.07
2.9	1.37	2.10	2.39	2.54	2.64	2.83	2.91	3.15
3.0	1.40	2.15	2.45	2.60	2.72	2.90	3.00	3.23
3.1	1.42	2.20	2.51	2.66	2.80	2.97	3.10	3.31
3.2	1.45	2.26	2.57	2.73	2.87	3.05	3.20	3.39
3.3	1.48	2.31	2.63	2.80	2.93	3.12	3.30	3.47
3.4	1.51	2.36	2.69	2.87	3.00	3.20	3.39	3.56
3.5	1.53	2.42	2.74	2.94	3.08	3.27	3.48	3.65
3.6	1.57	2.47	2.80	3.00	3.15	3.35	3.56	3.75
3.7	1.60	2.52	2.86	3.07	3.23	3.43	3.65	3.85

*Reprinted by permission from "The Electric Journal," Vol. IV, p. 299.

TABLE 16

	Power Factor
Incandescent lamps of all kinds	1.00
Arc lamps, including flaming arcs	0.65
Induction motors (running) up to 15 hp	0.80
Above 15 hp	0.85

where the wires are in conduit, when a size of 500,000 circ.mils or larger may be used. If larger wires are required to carry the load two or more can be employed in parallel. For example, find the drop on a 500,000-circ.-mil feeder carrying 300 amp. a distance of 500 ft. The direct-current drop is 6.4 volts. If the frequency is 60 cycles, the power factor 0.8 and the spacing 6 in., the drop factor is 2.88 and the alternating-current drop is 18.4 volts. No. 0000 cable is about one-half the size of 500,000-circ.mil cable; therefore, calculate the drop, using two No. 0000 cables instead of a single wire. The current per cable would be 150 amp., the direct-current drop would be 7.6 volts and the drop factor 1.74. Hence, the alternating-current drop would be only 13.2 volts, which is considerably less than for the single cable. Figuring the size of wire to give the same voltage drop as before (18.4 volts), we find that a No. 00 cable gives an alternating-current drop of 17.2 volts. That is, two No. 00 cables having a total cross-section of 266,200 circ.mils will carry a total load of 300 amp. with less drop than for a single 500,000-circ.mil cable with a great saving in copper. This saving often exceeds the additional cost of running two circuits instead of one, so this point should always be kept in mind when laying out alternating-current circuits. In this connection, it should be stated that wires which are run in multiple, as in the above case, should always be of the same size. For example, if a 500,000- and a 300,000-circ.mil cable were employed to take the place of one of 800,000 circ.mils the smaller wire would take more than its share of the load, and in some cases, might be overheated. This method can also be used for the calculation of three-phase and two-phase circuits by making certain modifications which will be explained later.

Hilliard Rack-and-Pinion Clutch Shifter

An interesting clutch-shifting device for use with the Hilliard clutch and manufactured by the Hilliard Clutch & Machinery Co., Elmira, N. Y., is illustrated in Fig. 2.

While to date this mechanism has been used exclusively in connection with Hilliard clutches, its application is not confined to this particular make, but it is equally adaptable to any clutch which has a sliding

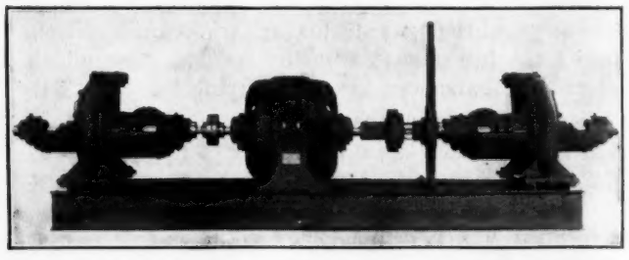


FIG. 1. SHIFTER ON CLUTCH BETWEEN PUMP AND MOTOR

member for engaging and in which can be cut the necessary groove to accommodate the clutch-shifter yoke.

This device is made either in solid or split form, and the operating mechanism is held in a set position on the shaft by two safety collars; the thrust for engaging the clutch is obtained by means of the rack and pinion. For operating the pinion, several devices may be employed, but preferably a handwheel, which can be attached by a key or a setscrew to the stub pinion shaft or to an extension shaft coupled to the short shaft provided. The device is convenient under certain conditions, say when it is desired to operate a clutch from the opposite side of a brick wall. In one case a 12-ft. extension shaft was attached to the short pinion shaft by a coupling, common pillow blocks being used for a bearing in the wall. On the end of the shaft an ordinary handwheel

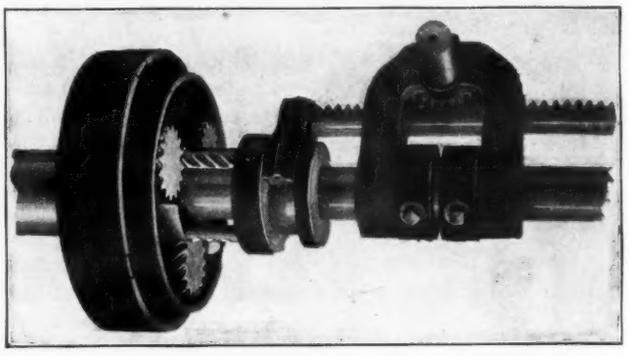


FIG. 2. RACK-AND-PINION CLUTCH SHIFTER

was attached, and although separated from the shaft by a brick wall, the operator had perfect control of the clutch.

There are many places where this device would prove useful. It is manufactured in three sizes. No. 1 size will accommodate a 2-in., No. 2 a 3-in. and No. 3 a $4\frac{7}{16}$-in. shaft. The yoke, suspended from the shaft, is equipped with grease cups which provide ample lubrication, and the device is efficient.

Fig. 1 illustrates an 8½-in. clutch of 7½-hp. capacity and shifter on the shaft of a 15-hp. motor that is used for driving two pumps running at 1200 r.p.m. One pump is coupled to the motor shaft direct, the other by means of the clutch. The convenience of the arrangement is apparent.

The Area of Chimneys should be proportioned to the quantity and quality of the fuel consumed per hour. Isherwood determined by experiments that the stack area should be from one-sixth to one-eighth the area of the grate, modified by the velocity of the gas. This in turn is influenced by the temperature of the gas and the height of the stack.

Safety-Valve Capacity—Below is given the number of square feet of heating surface served by a single 4-in. pop safety valve at 100 lb. gage pressure, under the requirements of the various rules noted. The assumption is made that the ratio between grate surface and heating surface is 1 to 40, and in such rules as require the rate of combustion to be assumed, it has been taken at such rate as would cause the evaporation of 160 lb. of water per square foot of grate surface per hour.

	Sq.Ft.
U. S. Government rule $\left(a = 0.2074 \frac{\text{weight of water evaporated per hr.}}{\text{absolute pressure}}\right)$	1740
Massachusetts rule $\left(a = 0.2139 \frac{\text{weight of water evaporated per hr.}}{\text{absolute pressure}}\right)$	1700
Ohio rule (same as Mass.)	1700
Detroit rule (same as Mass.)	1700
Memphis rule (same as Mass.)	1700
Board of Trade rule $\left(\frac{37.5}{\text{absolute pressure}}\right)$	1540
Newfoundland (same as Board of Trade rule)	1540
Alberta (same as Board of Trade rule)	1540
British Columbia (same as Board of Trade rule)	1540
Saskatchewan (same as Board of Trade rule)	1540
Ontario (same as Board of Trade rule)	1540
Philadelphia $\left(\frac{22.5}{\text{gage pressure} + 8.62}\right)$	2390
Indiana (0.33 sq.in. per sq.ft. grate)	1510
Average	1670
A.S.M.E. Boiler Code for water-tube boilers	1006
A.S.M.E. Boiler Code for fire tube boilers	1208

Will Quizz, Jr.

SYNOPSIS—Our observant friend, Will, while reading the advertising section of his technical journal, sees a statement that he cannot verify, so he carries the problem to Chief Teller.

"Say, Chief, I saw a statement last night that has me puzzled."

"What is it, Will?"

"An advertisement which says that a rise of 10 deg. in the temperature of the feed water represents a saving of 1 per cent. in the coal bill. I can't see how they get that ratio."

"Let's see if we can figure it out, Will. Take your steam tables and see what the total heat in steam is at, say atmospheric pressure."

"It is 1150, Chief."

"What does that 1150 mean?"

"It means that it requires 1150 B.t.u. to convert one pound of water from 32 deg. into steam at atmospheric pressure."

"Right, Will! Then 1 per cent. of the total heat would be what? We just had a little percentage the other day."

"One per cent., or one one-hundredth part of 1150, is 11.5, Chief."

"Then each 11.5 B.t.u. added to the feed water to be made into steam at that pressure would represent 1 per cent., would it not?"

"Sure."

"And 11.5 B.t.u. would raise the temperature of the feed about 11.5 deg., so that for this case a rise in temperature of 11.5 instead of 10 deg. would make a saving of 1 per cent., eh?"

"Yes, Chief, but the total heat is not the same for all pressures and that would make the percentage different, I should think."

"Yes, that is true, so look down the column of pressures and you will see that at about 25 lb. pressure, the total heat is 1160 and at 42 lb. it is 1170 and at 71 lb. it is 1180 and at 123 it is 1190, and when the pressure reaches 227 lb. the total heat is an even 1200 B.t.u. In each you simply point off two places, so in the latter case, of course, 12 deg. per lb. of feed water or 12 B.t.u. would represent 1 per cent. That part of the calculation is easy to understand, is it not, Will?"

"But, Chief, the feed water is seldom freezing cold. Wouldn't that change the figures or percentage?"

"It surely would, and that is what brings the figure down from 11.5 or 12 to about 10 for the ordinary case. For example, to change a pound of water at 32 deg. into steam of 100 lb. pressure takes 1186 B.t.u., but if the feed water were 200 deg., there would already be in it 168 B.t.u. more than in water at 32, so that there would have to be added in the boiler only 1186 — 168 = 1018 B.t.u., and the addition of 10.18 B.t.u. per lb., or the raising of the temperature 10.18 deg., would save 1 per cent. So it is true that ten degrees' difference in the temperature of feed water will make a difference of 1 per cent. when the temperature is around 200 deg., and this is where it ought to be, but as the steam tables are based on the total heat in the steam above 32 deg., the calculation must be from that point as a base. All the heat that the water contains above 32 deg., no matter from what source obtained, must be deducted from the original total heat, then the percentage of the remainder calculated as before, since we are interested only in the heat that has to be put into the water at a given temperature to convert it into steam at the desired pressure. The calculation, however, is just as easy as in the first instance, for all that is necessary is to subtract the amount of heat in the water above 32 deg. from the total heat in the steam as shown by the table at the desired pressure, then point off two places, as before. This will show you at once the number of degrees the water must be heated to equal 1 per cent. of the total heat required under these conditions.

"For example: The sun in heating the water in the pond to 78 deg. has contributed 46 B.t.u. per lb. toward converting it into steam which, for atmospheric steam, would be 4 per cent. of the total heat required. Since, as shown, 11.5 B.t.u. equals 1 per cent., then 46 would be 4 per cent. Then to complete the process there will be required 1150 — 46 = 1104 B.t.u. Pointing off two places as before, 11.04 is 1 per cent. of the remaining heat required, so that 11.04 deg. added to the feed water will save 1 per cent. in B.t.u. Now, suppose a small heater contributed 6 per cent. of the remaining 1104 B.t.u. or added 66¼ deg. to the feed water (1% of 1104 = 11.04 and 6% = 66.24), then 46 + 66 = 112 B.t.u. would have been added to the feed water, leaving 1150 — 112 = 1038. Then suppose an economizer in turn contributed 6 per cent. of the remaining 1038 B.t.u., or added 62.3 deg. to the feed water (1 per cent. of 1038 = 10.38 and 6 per cent. = 62.28 or, for easier calculation, 62.3), then 46 + 66 + 62.3 = 174.3 in all have been added, and the total heat the furnace would have to supply would then be 975.7 B.t.u. and the feed water is entering the boiler at a little over 32 + 174.3 = 206.3 deg.

"To sum up this part of the story: In the first calculation 11.5 deg. rise in temperature of the feed water equaled 1 per cent. of the total heat required; in the second, 11.04 deg. equaled 1 per cent. of the remaining heat required; in the third, 10.38 deg. equaled 1 per cent. of the remaining heat required. So you see there is no fixed amount which equals 1 per cent. under varying conditions, even with a 100 per cent. efficient plant."

"The 1 per cent. for ten degrees is only approximate, then?"

"That's all."

"And the saving is in heat units, not in coal?"

"Yes, but what's the difference? You have to burn coal to get heat units, and if you save half of your heat units you ought to save half of your coal."

"But the saving ought to be greater with a poor outfit than with a good one."

"How so?"

"Why, with a boiler of 80 per cent. efficiency I would only have to develop $\frac{1}{0.80} (= 1.25) \times 10 = 12.5$ B.t.u. in the furnace to put 10 B.t.u. into the steam, while with

a boiler of only 50 per cent. efficiency I would have to develop 20 B.t.u. in the furnace for each 10 in the steam. If the feed water is 10 deg. hotter it will save only 12.5 B.t.u. per lb. in the case of the 80 per cent. boiler, but 20 in the case of the 50 per cent. boiler."

"That's right, the heating of the feed water for a poor outfit saves more in heat units and in coal, but the same in per cent."

"How can that be?"

"What is 50 per cent. of 5 pounds?"

"Two and a half pounds."

"What is 50 per cent. of 3 pounds?"

"One and a half pounds."

"But it is 50 per cent. in each case."

"Sure."

"Well, with the 80 per cent. boiler you must develop, as you say, 12.5 B.t.u. in the furnace in order to get 10 into the steam. A saving of one B.t.u., or 10 per cent., in making the steam would make a saving of 1.25 B.t.u. in the furnace. With the 50 per cent. boiler you would have to develop 20 B.t.u. in the furnace to get 10 into the steam, and the saving of 1 B.t.u., or 10 per cent., in making the steam would save 2 B.t.u. in the furnace. Do you get me?"

"Yes."

"For the poor boiler the saving is 2 B.t.u. as against 1.25 for the good boiler."

"Yes."

"But 2 is 10 per cent. of 20 and 1.25 is 10 per cent. of 12.5, so that the percentage of saving is the same in both cases, notwithstanding the actual saving is greater in the case of the less efficient boiler. If you save half your coal when you are using 10 tons a day, it will be more tons than it would if you saved half of only six tons a day, but it will be one-half in both cases.

"The next question arises as to how much each B.t.u. is worth in money, which means the cost of the fuel, the labor, etc. If the fuel is cheap the loss, of course, is not so great when heat is wasted, yet the price per ton may be low and still the cost of the B.t.u. it contains or that transferred to the boiler may be high from several causes; low heat value, high cost of labor and unfavorable location being among the things which make it so. Therefore, the calculation must take in the cost of the B.t.u. at different places, by the same course of reasoning. If each B.t.u. in the fuel costs twice as much at one place as at another, then the heat put into the water from some other source is twice as valuable. So you see, Will, only the first general statement can be made which will be universally correct and comprehensive.

"In short the B.t.u. in the water must be considered 100 per cent. It is all there. The efficiency of the B.t.u. in the coal is variable and dependent on the equipment. The cost of the B.t.u. in the coal influences the value of the B.t.u. in the water, and the cost of getting the heat transferred from the coal to the water must be considered for a complete analysis. Does the subject seem clear to you now, Will?"

"Yes, thank you, Chief, and it has given me a better understanding of the necessity of watching the feed-water temperature more closely. I think I'll take more interest in that thermometer on the feed line after what you've told me."

Hill Gage-Glass

The Hill Pump Valve Co., 18 E. Kinzie St., Chicago, Ill., has recently perfected a new gage-glass possessing two distinctive features. It is easy to read and is protected against breakage to an unusual degree. No metal touches the glass. It is held in place by rubber gaskets and is free to expand or contract. Three supporting arms keep the upper and lower connections in alignment and protect the glass against breakage. Should it break, the arms will keep the broken pieces within the inclosure. On the inside the arms are white, so that the glass may be easily read from any angle. To prevent condensation from running down the sides of the glass and making it less transparent, a funnel has been provided and is centered so that the water will drop down through the center of the glass. The rubber gasket and the funnel tend to prevent corrosion at the top of the glass, and the former reduces breakage, which is more or less common when inserting a glass.

HILL GAGE-GLASS

The Discovery of Oxygen is generally credited to Dr. Joseph Priestly, an English clergyman and scientist. The date, Aug. 1, 1774, is commemorated as the birthday of modern chemistry. At about the same time two others made the same discovery: Scheel, a Swedish apothecary, who called it "fire air"; and Lavoisier, a French chemist, who called it oxygen, meaning "acid former." To Lavoisier is due the credit for the true explanation of combustion.

Development of Switchboards—In the modern electric generating station the protective devices represent the highest class of design and workmanship in the entire installation, while the cost of the switchboard frequently nearly equals that of the plant controlled by it. In the old days, however, says J. Gardner, writing in "Vulcan," few or no protective devices were installed. For instance, in a power station still running there are several 2000-volt 300-kilowatt single-phase generators controlled by open single-pole switches of the simplest type and without even a fuse in circuit; one side of the system is grounded. Everything operates quite satisfactorily until a cable gets grounded or someone makes a mistake; then there is a serious accident. A case of this kind recently occurred. A direct-current generator coupled to a steam engine was being run up in readiness for paralleling with other machines. When the volts were about 100 the attendant closed the main switch of this machine by mistake. Although the fault was discovered immediately, the rush of current into the machine pulled the armature winding partly round the core, and some of the commutator segments were nearly forced out of the V rings. The driving pins in the armature were sheared off and the insulation of the core was damaged. The armature had to be entirely rewound and the commutator rebuilt.

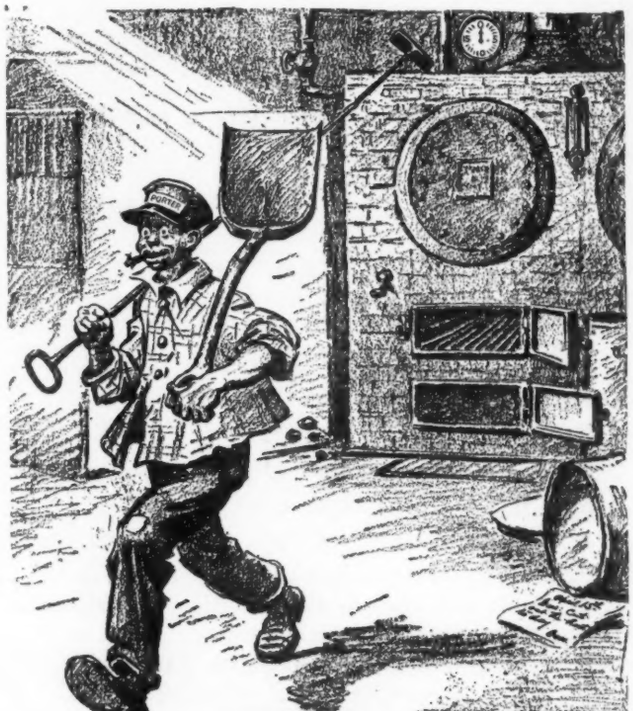
JUST FOR FUN

Failed to Recognize a Thermometer

In our plant we have both steam and hot-water boilers. The chief engineer hired a fireman recently, who had had an engineer's license for over fifteen years and who knew all (?) about engines and boilers. One day the Chief asked me to see if the water was hot enough and to look at the fire, as the demand was heavy. I looked and said, "Yes, it's 160."

After that the fireman, when asked how the fire was, would say, "Fine! I have 160 lb. on it," never realizing that instead of 160 lb. of steam he had 160 deg. It was about three weeks before he "caught on" that it was a hot-water boiler.—*Antoinette Vonasek, New York City.*

"In the Good Old Summer Time"



The retreat from the firing line.

(From the New York "World")

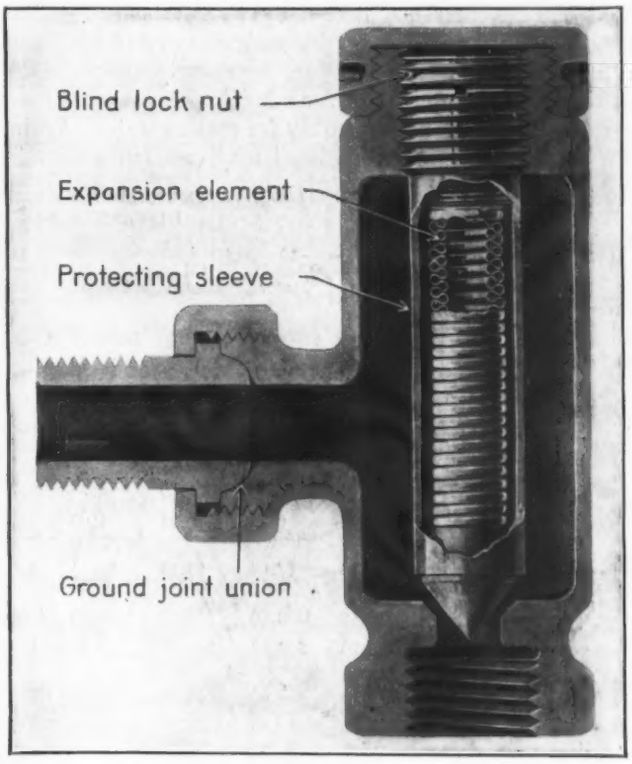
When the Wind Fails

A windmill for pumping water from a mine 60 ft. deep, recently installed and having a wheel mounted on a tower 60 ft. high on the bank of the mine, was an object of interest. Beside the railroad track the section gang during the noon meal discussed the unreliability of power that was available only when the wind was blowing.

The typical section boss, a middle-aged man, had said nothing for some time, but finally he could stand it no longer and he broke in with: "You fellows have bright ideas. Do you think these people are going to wait for wind when they have water to pump? See those cranks, arms and bevel gears. They can put wind on those vanes any time that they have a mind to." This ended the discussion, as no subordinate dared to question the knowledge of his superior.—*T. H. Reardon, Pittsfield, Mass.*

Winn Expansion Trap

The Winn trap shown in section in the accompanying illustration is designed for use on vacuum vapor and modulation systems of heating. It consists of an outer casing made entirely of brass, the valve seat forming an integral part of the casing. A ground-joint union tail piece attaches the trap to the heating unit. In the casing an expansion element, consisting of a seamless corrugated bronze tube which is filled with an expansion liquid, is inserted. The valve head is attached to the tube, and when steam comes in contact with the latter. the liquid



Details of the Winn Expansion Trap

inside expands and pushes the valve head to its seat. As soon as water collects around the tube the liquid contracts and the valve opens, permitting the water to pass through into the return line. A long sleeve guides the valve head to its seat and protects the corrugated element against scale and dirt.

The Winn trap is a modification of the "Welo" trap, which has been on the European market for many years. It is now being built in the United States by the Detroit Steam Specialty Co., Kerr Building, Detroit, Mich.

One of the Effects of Superheat—Superheating steam increases its volume a different percentage for different pressures and temperatures. For example: Steam at 100 lb. pressure superheated 100 deg. expands approximately 16 per cent., while 200 deg. increases its volume 31 per cent. or 15 per cent. for 100 deg., and 300 deg., 45 per cent., or 14 per cent. for 100 deg. For any desired case see the steam tables giving the specific volume of saturated steam, subtract this from the specific volume for the degree of superheat, divide by the specific volume of the saturated steam, and the result will be the percentage of increase in volume. (The same process gives the percentage difference in volume between two different degrees of superheat.) The amount of work steam of a given pressure will do is very nearly in direct proportion to its volume, hence one of the advantages of superheating.

Initial and Operating Costs of Refrigeration Plants

By Robert P. Kehoe

As the figures given by manufacturers to represent first cost, cost of operation, upkeep, etc., are often incomplete, the following tables will be found useful by operators and owners interested in refrigerating and ice-making plants of comparatively small capacity.

Table 1 refers to refrigerating plants. No particular application has been considered and the data may be used for any of the branches of refrigeration, such as general cold storage, markets, hotels, apartment houses, water-cooling plants, fur storage, drygoods stores, and hospitals.

The estimated first costs are necessarily approximate. A refrigerating equipment for a hotel will cost more than a refrigerating plant used solely for cooling water. Again, the same size plant in one hotel may cost more than in another. The figures are a good average, and the comparison between the costs of plants with different drive is quite correct.

Those who now operate plants and know what their equipment cost can use the table to advantage in adding or deducting to the same extent as indicated in the table to determine the difference in cost of other methods of drive. Then by applying the actual costs of labor and fuel, which are known, in the same manner, it may be ascertained how economically each plant is performing and if improvement is possible.

Refrigerating plants of from ten to twenty-five tons' daily capacity are seldom operated by men engaged to do nothing else, but usually by men required for operating other machinery. This has been considered in the table. The figures may be easily corrected to suit local conditions, and the price of fuel also regulated to correspond. The table represents a fair average.

The 60 per cent. yearly load factor assumed should be close to actual conditions in the majority of plants. It will be noted that the labor charge has been carried through the whole year. The 10 per cent. added for depreciation and repairs can be divided about half and half. A 5 per cent. yearly depreciation means complete renewal in fifteen years if the 5 per cent. is calculated as a sinking fund; 5 per cent. yearly for repairs and incidentals should be ample. No building has been taken into consideration because small refrigerating plants are usually located in some part of an existing building.

The advantage of making calculations of operating costs on a yearly basis cannot be doubted. In fact, the daily operating expense alone is misleading, particularly when the yearly load factor is low and a comparatively short period of operation must bear the depreciation and upkeep expense for the year.

The total cost per ton of refrigeration per day is interesting when compared to the cost of using ice for the same purpose. Ice is seldom delivered for less than $2.50 to $3 per ton, even in large quantities, and often the price is $3 to $4. The table proves that much saving can be accomplished by the refrigerating plant, without considering greater convenience, elimination of slop from melting ice and better preservation of perishable goods under lower temperatures.

TABLE 1. COMPARISON OF INITIAL INVESTMENT, DAILY AND YEARLY COSTS OF OPERATION OF REFRIGERATING PLANTS, WITH DIFFERENT KINDS OF MOTIVE POWER

Refrigerating capacity in tons per day of 24 hours..	10			15			20			25		
Kind of Power	Steam	Electric Motor	Oil Engine	Steam	Electric Motor	Oil Engine	Steam	Electric Motor	Oil Engine	Steam	Electric Motor	Oil Engine
Investment for complete mechanical equipment of refrigerating plant.....	$5000.00	$4500.00	$5300.00	$7000.00	$6400.00	$7400.00	$8000.00	$7300.00	$8400.00	$9200.00	$8400.00	$9500.00
Daily operating expense: Labor during night and day (assuming that engineers, etc., are also required for other purposes)	2.00	1.50	1.50	3.00	2.00	2.00	3.50	2.50	2.50	4.00	3.00	3.00
Fuel: Coal @ $3.50 per ton; oil @ 3½c. per gal.; current @ 2c. per kw. hour....	3.50	4.80	1.50	4.75	7.20	1.80	6.00	9.60	2.20	7.00	12.00	2.50
Ammonia, oil, waste and supplies.....	0.75	0.75	0.75	1.00	1.00	1.00	1.25	1.25	1.25	1.50	1.50	1.50
Net operating expense per day.....	$6.25	$7.05	$3.75	$8.75	$10.20	$4.80	$10.75	$13.35	$5.95	$12.50	$16.50	$7.00
Daily operating expense for 60 per cent. of year at full capacity.....	1350.00	1523.00	810.00	1889.00	2204.00	1037.00	2322.00	2884.00	1286.00	2700.00	3564.00	1512.00
Full labor expense for balance of year.....	288.00	216.00	216.00	432.00	288.00	288.00	504.00	360.00	360.00	576.00	432.00	432.00
10 per cent. of investment to cover depreciation, repairs and incidentals...	500.00	450.00	530.00	700.00	640.00	740.00	800.00	730.00	840.00	920.00	840.00	950.00
Total annual expense.....	$2138.00	$2189.00	$1556.00	$3021.00	$3132.00	$2055.00	$3626.00	$3974.00	$2486.00	$4196.00	$4836.00	$2894.00
Total expense per ton of refrigeration per day....	$1.00	$1.00	$0.72	$0.93	$0.96	$0.64	$0.84	$0.92	$0.58	$0.78	$0.89	$0.54

The economy of oil engines as compared with ordinary steam plants and electric motors using central-station current at average rates is quite evident. In the smaller sizes of refrigerating and ice-making plants considered in the tables, the cheaper cost of operation is even more pronounced because small steam plants are not usually economical, while small oil engines perform almost as well as large units.

It may not always be advisable to install an oil engine, on account of local conditions which may favor a steam engine or electric motor. Steam may be required for other purposes. Sometimes the power plant may have to be located in such close quarters that only an electric motor can be used to preserve sanitary conditions. Sometimes it would be inadvisable to place an oil engine or a steam unit in the crowded basement of a hotel, restaurant or hospital where other work is going on and perhaps where foodstuffs are handled. But if the location and requirements do not favor other power, the oil engine will afford a marked saving in the yearly expense.

The table which refers to ice plants is arranged on a basis similar to the table for refrigerating plants. The cost of a special building is included, and the labor is calculated to be used for the ice plant alone. Only half the labor is included during the balance of each year when the plant is shut down or not operated at full ca-

pacity. Moreover, special tabulations are given for different yearly load factors. The importance of this factor is indicated by the wide difference in cost of production. For example, the 25-ton oil-engine-driven plant shows a total producing cost of $3.27 per ton when the yearly output is equivalent to three months' full operation, while the same plant producing the equivalent of seven months' full operation reduces the cost per ton to $1.82.

TABLE 2. COMPARISON OF INITIAL INVESTMENT, DAILY AND YEARLY COST OF OPERATION OF ICE PLANTS, WITH DIFFERENT KINDS OF MOTIVE POWER

Capacity in Tons of Ice per Day of 24 Hours	10			15			20			25		
Kind of Power	Steam,	Electric Motor,	Oil Engine,	Steam,	Electric Motor,	Oil Engine,	Steam,	Electric Motor,	Oil Engine,	Steam,	Electric Motor,	Oil Engine,
Type of Plant	Distilled Water	Raw Water	Raw Water	Distilled Water	Raw Water	Raw Water	Distilled Water	Raw Water	Raw Water	Distilled Water	Raw Water	Raw Water
Investment:												
Mechanical equipment complete	$8,500.00	$7,500.00	$8,500.00	$11,500.00	$10,000.00	$11,500.00	$12,500.00	$11,000.00	$12,500.00	$15,000.00	$13,300.00	$15,000.00
Building	3,500.00	3,000.00	3,000.00	4,500.00	4,000.00	4,000.00	5,500.00	5,000.00	5,000.00	6,500.00	6,000.00	6,000.00
Total investment, excluding land)	$12,000.00	$10,500.00	$11,500.00	$16,000.00	$14,000.00	$15,500.00	$18,000.00	$16,000.00	$17,500.00	$21,500.00	$19,300.00	$21,000.00
Daily operating expense:												
One day engineer	3.00	3.00	3.00	3.00	3.00	3.00	$3.50	$3.50	$3.50	$3.50	$3.50	$3.50
One night engineer	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	3.00	3.00	3.00
One day tankman	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
One night tankman	.....	.....	.....	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Extra labor	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.00	.....	.....
Fuel: Coal @ $3.50 per ton; oil @ 3½c. per gal.; current @ 2c. per kw.-hr.	7.00	12.00	2.63	10.00	18.00	3.94	13.00	23.00	5.25	15.50	30.00	6.56
Ammonia, oil, waste and supplies	1.50	1.50	1.50	2.25	2.25	2.25	3.00	3.00	3.00	3.75	3.75	3.75
Net operating expense per day	$16.00	$21.00	$11.63	$21.75	$29.75	$15.69	$26.00	$37.00	$18.25	$31.75	$44.25	$20.81
Yearly Summary—50 Per Cent. Load Factor (6 Months' Full operation)												
Daily operating expense during period of full operation, in dollars	$2,880.00	$3,780.00	$2,094.00	$3,915.00	$5,355.00	$2,825.00	$4,680.00	$6,660.00	$3,285.00	$5,715.00	$7,965.00	$3,746.00
Half of labor expense for balance of year	675.00	675.00	675.00	855.00	855.00	855.00	900.00	900.00	900.00	1,125.00	945.00	945.00
Fixed charges:												
5 per cent. depreciation on cost of equipment	425.00	375.00	425.00	575.00	500.00	575.00	625.00	550.00	625.00	750.00	665.00	750.00
3 per cent. depreciation on building	105.00	90.00	90.00	135.00	120.00	120.00	165.00	150.00	150.00	195.00	180.00	180.00
5 per cent. total investment for repairs, taxes, water and incidentals	600.00	525.00	575.00	800.00	700.00	775.00	900.00	800.00	875.00	1,075.00	965.00	1,050.00
Total annual expense	$4,685.00	$5,445.00	$3,859.00	$6,280.00	$7,530.00	$5,150.00	$7,270.00	$9,060.00	$5,835.00	$8,860.00	$10,720.00	$6,671.00
Number of tons ice produced annually	1,800.00	1,800.00	1,800.00	2,700.00	2,700.00	2,700.00	3,600.00	3,600.00	3,600.00	4,500.00	4,500.00	4,500.00
Total cost per ton of ice per annum	2.60	3.03	2.15	2.33	2.79	1.91	2.02	2.52	1.62	1.97	2.38	1.48
Average selling price to make 10 per cent. on investment	3.26	3.60	2.79	2.93	3.31	2.48	2.52	2.97	2.08	2.45	2.81	1.96
Yearly Summary—42 Per Cent. Load Factor (5 Months' Full Operation)												
Daily operating expense during full operation	$2,400.00	$3,150.00	$1,745.00	$3,262.00	$4,463.00	$2,204.00	$3,900.00	$5,550.00	$2,738.00	$4,763.00	$6,638.00	$3,122.00
Half of labor expense for balance of year	788.00	788.00	788.00	998.00	998.00	998.00	1,050.00	1,050.00	1,050.00	1,313.00	1,103.00	1,103.00
Fixed charges	1,130.00	990.00	1,090.00	1,510.00	1,320.00	1,470.00	1,690.00	1,500.00	1,650.00	2,020.00	1,810.00	1,980.00
Total annual expense	$4,318.00	$4,928.00	$3,623.00	$5,770.00	$6,781.00	$4,672.00	$6,640.00	$8,100.00	$5,438.00	$8,096.00	$9,551.00	$6,205.00
Number of tons of ice produced annually	1,500.00	1,500.00	1,500.00	2,250.00	2,250.00	2,250.00	3,000.00	3,000.00	3,000.00	3,750.00	3,750.00	3,750.00
Total cost per ton ice per annum	2.88	3.29	2.42	2.56	3.02	2.06	2.21	2.70	1.81	2.16	2.55	1.70
Average selling price to make 10 per cent	3.68	3.99	3.20	3.27	3.64	2.76	2.81	3.23	2.39	2.73	3.07	2.26
Yearly Summary—33 Per Cent. Load Factor (4 Months' Full Operation)												
Daily operating expense during full operation	$1,920.00	$2,520.00	$1,396.00	$2,610.00	$3,570.00	$1,883.00	$3,120.00	$4,440.00	$2,190.00	$3,810.00	$5,310.00	$2,497.00
Half of labor expense for balance of year	900.00	900.00	900.00	1,140.00	1,140.00	1,140.00	1,200.00	1,200.00	1,200.00	1,500.00	1,260.00	1,260.00
Fixed charges	1,130.00	990.00	1,090.00	1,510.00	1,320.00	1,470.00	1,690.00	1,500.00	1,650.00	2,020.00	1,810.00	1,980.00
Total annual expense	$3,950.00	$4,410.00	$3,386.00	$5,260.00	$6,030.00	$4,493.00	$6,010.00	$7,140.00	$5,040.00	$7,330.00	$8,380.00	$5,737.00
Number of tons of ice produced annually	1,200.00	1,200.00	1,200.00	1,800.00	1,800.00	1,800.00	2,400.00	2,400.00	2,400.00	3,000.00	3,000.00	3,000.00
Total cost per ton of ice per annum	3.30	3.68	2.82	2.92	3.35	2.50	2.50	2.98	2.10	2.45	2.79	1.91
Average selling price to make 10 per cent	4.30	4.53	3.78	3.81	4.13	3.31	3.25	3.65	2.83	3.17	3.43	2.61
Yearly Summary—25 Per Cent. Load Factor (3 Months' Full Operation)												
Daily operating expense during full operation	$1,440.00	$1,890.00	$1,047.00	$1,958.00	$2,678.00	$1,412.00	$2,340.00	$3,330.00	$1,643.00	$2,858.00	$3,983.00	$1,873.00
Half of labor expense for balance of year	1,013.00	1,013.00	1,013.00	1,283.00	1,283.00	1,283.00	1,350.00	1,350.00	1,350.00	1,688.00	1,418.00	1,418.00
Fixed charges	1,130.00	990.00	1,090.00	1,510.00	1,320.00	1,470.00	1,690.00	1,500.00	1,650.00	2,020.00	1,810.00	1,980.00
Total annual expense	$3,583.00	$3,893.00	$3,150.00	$4,741.00	$5,281.00	$4,165.00	$5,380.00	$6,180.00	$4,640.00	$6,566.00	$7,211.00	$5,271.00
Number of tons of ice produced annually	900.00	900.00	900.00	1,350.00	1,350.00	1,350.00	1,800.00	1,800.00	1,800.00	2,250.00	2,250.00	2,250.00
Total cost per ton ice per annum	4.00	4.33	3.50	3.51	3.91	3.08	3.00	3.43	2.58	2.94	3.18	2.34
Average selling price to make 10 per cent	5.33	5.50	4.76	4.69	4.94	4.23	4.00	4.31	3.55	3.89	4.04	3.27
Yearly Summary—58 Per Cent. Load Factor (7 Months' Full Operation)												
Daily operating expense during full operation	$3,360.00	$4,410.00	$2,442.00	$4,468.00	$6,248.00	$3,295.00	$5,460.00	$7,770.00	$3,833.00	$6,668.00	$9,293.00	$4,370.00
Half of labor expense for balance of year	788.00	788.00	788.00	998.00	998.00	998.00	1,050.00	1,050.00	1,050.00	1,313.00	1,103.00	1,103.00
Fixed charges	1,130.00	990.00	1,090.00	1,510.00	1,320.00	1,470.00	1,690.00	1,500.00	1,650.00	2,020.00	1,810.00	1,980.00
Total annual expense	$5,278.00	$6,188.00	$4,320.00	$6,976.00	$8,566.00	$5,763.00	$8,200.00	$10,320.00	$6,533.00	$10,001.00	$12,206.00	$7,453.00
Number of tons of ice produced annually	2,100.00	2,100.00	2,100.00	3,150.00	3,150.00	3,150.00	4,200.00	4,200.00	4,200.00	5,250.00	5,250.00	5,250.00
Total cost per ton ice per annum	2.51	2.95	2.06	2.21	2.72	1.83	1.95	2.45	1.55	1.90	2.32	1.42
Average selling price to make 10 per cent	3.08	3.45	2.61	2.72	3.16	2.33	2.38	2.83	1.97	2.31	2.69	1.82

Testing and Repairing Pyrometers

By J. Lucas

SYNOPSIS—Describes the fundamental construction of most types of pyrometers, enumerates their faults and shows how their troubles may be corrected. Directions are given for making an accurate pyrometer of material, most of which may be found about the plant.

Types of Pyrometers

The mechanism of most pyrometers on the market is actuated by the expansion and contraction of liquid mercury or metals.

Fig. 1 shows a straight-stem pyrometer, Fig. 2 a high-temperature mercury thermometer, and Fig. 3 a horizontal-face or bake-oven pyrometer. Fig. 4 shows a section of the stem of a straight-stem instrument. A ¾-in. brass pipe acts as a casing for a copper rod *B* welded to a plug *C* screwed into the bottom of the pipe. A collar *D* fastened to the pipe serves as a guide for the rod. The top end of the copper rod is countersunk to receive the end of a lever which transmits the movement of the rod under expansion or contraction to a hand on a dial. The length of the copper rod varies according to the temperature range it is desired to register. Some straight-stem instruments use a copper pipe on the lower end of a brass rod. Other pyrometers have a stem made of a piece of graphite on which is mounted a brass rod, as shown in Fig. 5. The dial, its mechanism and the case are fastened to the end of the pyrometer stem so that the expanding and contracting element is held between two points, one at the lower end of the pipe, the other at the pointer-operating lever. The coefficient of expansion of the stem tube and that of the rod are different, and the rod always expands or contracts more than the pipe, its movement being multiplied by levers in the dial casing.

Fig. 6 shows the interior of a vertical-face instrument. When the rod *A* in the stem expands it transmits its movement to the pivoted pin *B* and to the lever *C*, which carries a rack operating a pinion to which the pointer is attached. The spring *D* fastened to the lever exerts a constant pull on the pivoted pin and holds it in its position.

The dial end of a horizontal-face instrument is shown in Fig. 7. The movement of the expanding element is transmitted by a pivoted pin, as in Fig. 6.

Fig. 8 shows a mercury pyrometer. A heavy, seamless steel tube with a $\frac{1}{16}$-in. hole at *A* holds the mercury. The spring *B* is welded to the cap of the tube, the other end connecting with a lever, as shown. The tube and spring are filled with mercury by holding both upside down; before they are filled the end of the tube is welded and sealed. The movement of the spring is not usually allowed to exceed ¼ in. When it does, mercury is let out of it by unscrewing the stem at *C* until the expansion is ¼ in. One should make sure that the tube is screwed in tight again, as this joint will sometimes leak mercury when it is supposed to be tight.

Pyrometer Troubles

Sometimes the pointer on the dial will move in jumps instead of slowly. This indicates that there are loose joints somewhere. The bottom plug may be loose or dirt may have collected around the guide collar (*D*, Fig. 4), preventing free movement of the rod. When this happens the rod will bend as indicated by the dotted lines (Fig. 4), and of course the instrument cannot indicate correctly. To remedy this take the case off the stem (pipe), unscrew the bottom plug and wash the stem and rod with gasoline. The rod must be straightened before the instrument is reassembled. Now put the stem in a pail or vessel of boiling water for a few minutes and set the pointer on the 212-deg. F. mark. Whenever there is no movement of the pointer for variations in temperature the usual cause is that the pivoted pin has fallen from its bearing.

Troubles Caused by Graphite Rod

The graphite-rod pyrometer is subject to a peculiar trouble. After long service the rod seems to slowly disintegrate, its diameter becoming less and less until its expansion for a given temperature rise is not what the instrument was calibrated for. The remedy, of course, is the use of a new rod of the original diameter and length.

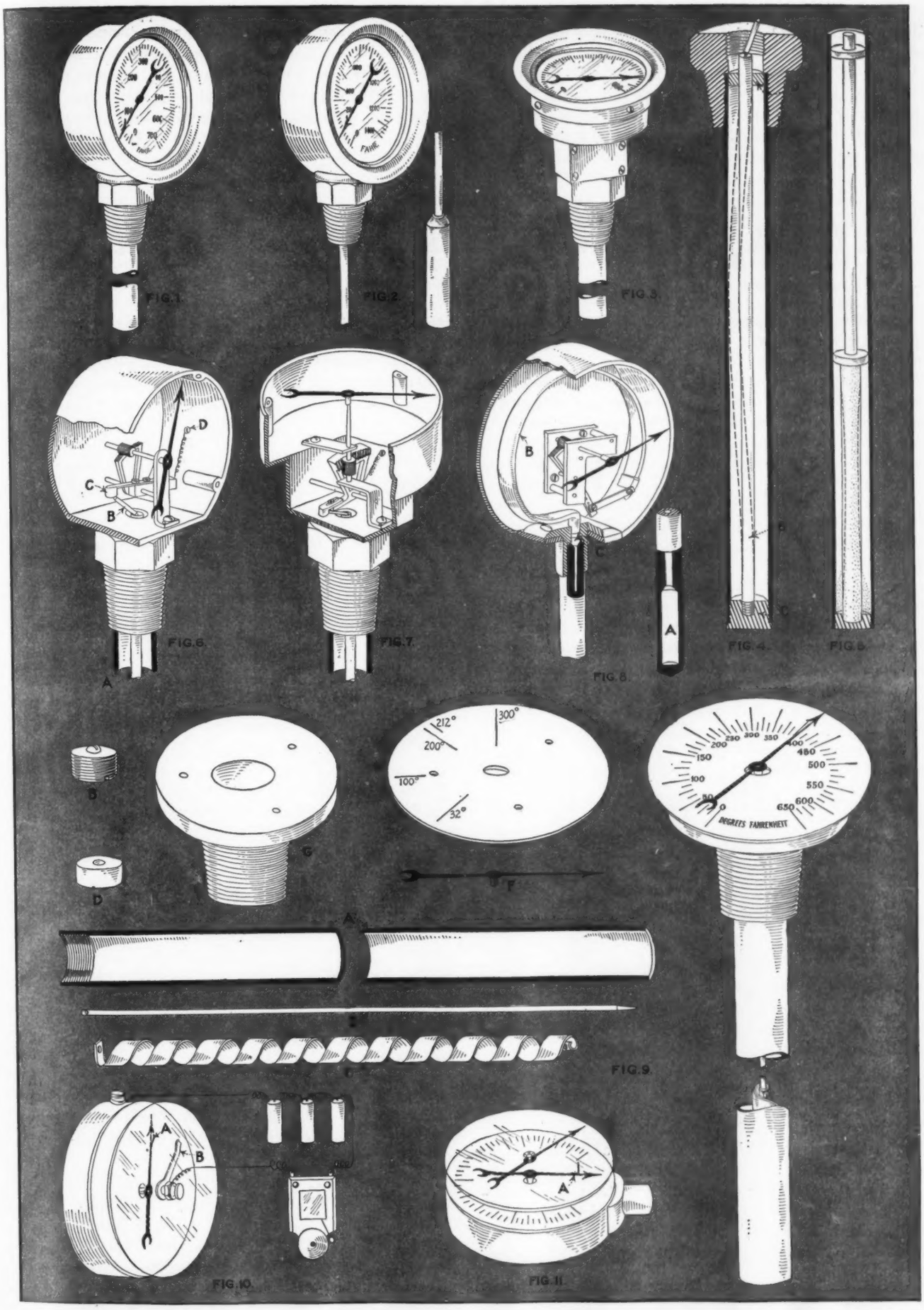
A "Home-Made" Pyrometer

Many plants and shops where a pyrometer is needed only occasionally will find the one described herewith serviceable and accurate. A piece of $\frac{1}{16}$-in. steel pipe *A*, 1 in. diameter and 24 in. long, is threaded inside at one end to receive the plug *B*, and the other end is threaded on the outside to screw into the base of the case. A brass spring strip *C* $\frac{1}{32}$x¼x30 in. is formed spirally, having ½-in. pitch and ½-in. diameter. This spring will be about 10 in. long. One end is brazed to the plug *B*, and the spring and plug are put into the pipe *A*. The guide-disk *D* is then brazed or soldered to the other end of the pipe. This disk has a $\frac{3}{32}$-in. hole to guide the steel spindle *E*, $\frac{1}{16}$ in. diameter, which should be fastened to the lower end of the spring by a rivet or screw before the spring is put into the pipe. The top end of the spindle should be pointed to permit forcing on a 5-in. hand or pointer *F*. A piece of tin or sheet iron 6 in. diameter is used for the dial. The flange *G* is now screwed into the pipe, the dial fastened, and the pointer laid near-by, ready to be forced on the spindle. The instrument is now ready for calibration.

Pack the stem for its full length in a pail of chopped ice. After about ten minutes force on the pointer, and under and to one side mark 32 deg. F., the freezing point. Next immerse the stem in water kept at 100 deg. F., as indicated by a correct thermometer. When the pointer will move no more make the 100-deg. F. mark on the dial. Next heat the water to 200 deg. and mark the dial. Also, mark it at 212 deg. The stem is next immersed in crude oil heated to 300 deg. F. For the rest of the dial the spaces between 300 and 400, 400 and 500, etc., may be divided off equally up to 650 deg. F., for which range the instrument is well suited.

Pyrometer Alarm

Sometimes it is desired to call the attendant's attention by alarm when a certain temperature has been



INDICATING PYROMETERS AND THEIR MECHANISM. FIG. 9 SHOWS ONE THAT MOST ANY ENGINEER CAN MAKE

reached. This may be done by putting on the pointer pin an adjustable piece *A*, Fig. 10, which is held in position by a thumb-nut. A light flat spring is soldered to the pointer and contact poles are fastened to the instrument, as shown. The movable contact piece *B* is set over the desired temperature mark on the dial, and when this is reached the spring on the pointer makes contact, closing the circuit and ringing a bell.

Should it be desired to have the pyrometer indicate the highest point reached after the temperature has fallen, a dummy pointer may be used. This is an ordinary pointer mounted as shown in Fig. 11, and which is free to move so that the indicating pointer may push it around by engaging the projection *A* on the dummy. Usually, the dummy pointer is painted red or white so it can be easily distinguished.

Lining Up Small Turbine Sets

By J. H. Hurley*

The successful operation of any turbo-generator, turbo-pump or turbo-blower set depends so much upon the satisfactory alignment of the complete unit that too much attention cannot be paid to this matter when erecting these machines. The idea that because the unit is on a cast-iron bedplate the latter cannot be sprung is erroneous, as it is easy to twist a bedplate by wedging unevenly or by pulling down holding-down bolts at, say, opposite corners.

Another mistaken idea is that because a machine is fitted with a flexible coupling, alignment between the two ends of the unit is unnecessary. The so-called flexible coupling will take care of a small amount of misalignment and also should eliminate the thrust of one machine being thrown onto the other. In other words, it has the effect of making each end of the machine self-contained, but owing to the high speed at which these machines run it should never be assumed that a flexible coupling will satisfactorily take care of any appreciable misalignment, and the machines should be lined up with a flexible coupling just as accurately as if the coupling were solid.

The rough-and-ready method of lining up with a straight-edge across the two coupling faces, Fig. 1, often

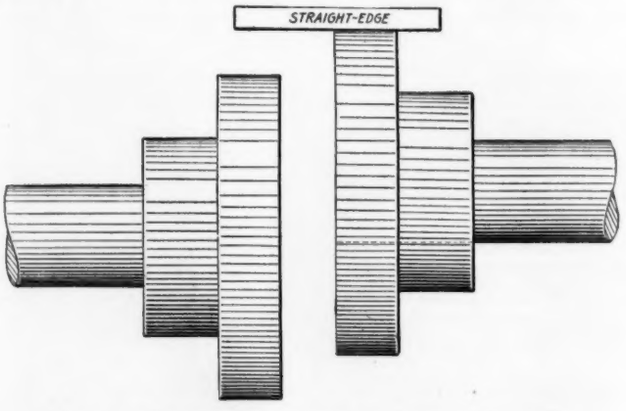


Fig. 1. Lining Up with the Straight-Edge

is satisfactory, but this is only so when the couplings are true in themselves. This condition, however, is often by no means the case and couplings are frequently found to be out of true on their own shaft. To take care of this possibility, therefore, the following method of lining up is suggested, taking into account all the possibilities of untrue couplings in addition to the regular and orthodox method of lining up.

Try out couplings to ascertain if they run true by placing a straight-edge on one half of the coupling, then by the use of a thickness gage, Fig. 2, ascertain the high and low side of one half by rotating one half, then take a mark at 90 deg. from those points and use those

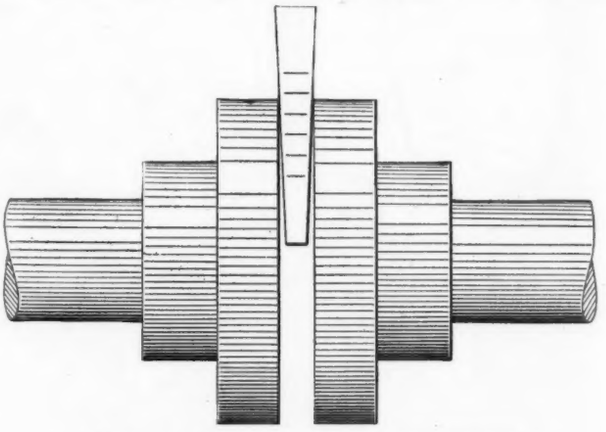


Fig. 2. Application of the Wedge

points exclusively both for horizontal and vertical lines. Then in turn let this half stand still and rotate the opposite half in like manner. Place the straight-edge on both faces at those points until both flanges are flush on the sides, allowing the regular amount on the turbine side, top and bottom, for heat expansion for the generator, boiler-feed pump, circulating pump, blowers or other sets according to their different temperatures when operating.

This same method should be used on the faces of couplings, as it happens sometimes that couplings run out on the faces when they run perfectly true on the sides. In this case a taper wedge may be used to find the high and the low points. Then, when those points are obtained, use such liners as may be required to bring the faces parallel.

It is generally understood that bases are leveled at the works before the sets are bolted down. If this is properly done the sets may be placed for grouting by inserting wedges at all points where it will effect the coupling in the direction required.

Should the set be erected on the job, then follow the usual course by first leveling the base and allowing height enough for substantial grouting, which is usually about ¾ in.; then locate the sets as described.

Always use metal liners or wedges, as wood is apt to shift on account of the dampness of the grouting, with disastrous results. When the grouting is properly set the sets should be checked and the bearings properly

*Mechanical department, the Terry Steam Turbine Co.

washed out before oil is put in. The governor should be worked back and forth to free it and remove rust which may have accumulated while standing.

Many couplings are not drilled to jig and, therefore, the pins will only fit in the holes which are matched. Couplings are generally stamped in a case like this, showing where they should be matched.

When sets are doweled at the works, or if for any reason it is necessary to change liners, the holes should be again reamed when the dowels are taper and should not be driven hard enough to stretch the metal, but tapped slightly until the tapping becomes solid.

All flanges should be brought to the turbine or pump square, and when rigid no soft gasket should be used to draw the sets out of line and shear the dowels.

In lining up generators, place chalk marks at one point on each end of the armature; all aligning should be done from these marks with the use of a wedge or a feeler, as taking several points on the armature would not be correct on account of the high spots in the banding. In all cases make sure that the core of the armature and the core of the polepieces are equally centered with each other so as not to cause a thrust on the turbine bearing. The core of the armature is always longer than the polepieces.

It is hard to decide how far out couplings can be allowed to be and still work satisfactorily, but the writer would say that if they are out more than $^1/_{64}$ in. any way, special care should be exercised in starting the machine, and if it does not run smoothly enough this should be reported, with a special remark about the couplings being out of the true, so that the matter may be taken up with the coupling makers.

The mixture for grouting in a machine should be half pure cement and half sand. After grouting, the machine should be allowed to set for 48 hours. Foundation bolts should be left loose or screwed down by hand until after the concrete is set, when they may be tightened firmly.

In lining up, as previously mentioned, use iron wedges only. They should be placed under the spot where the weight comes and as near the foundation bolts as possible.

Cold-Air Intake Duct for Air Compressors

By R. S. Bayard

SYNOPSIS—Shows by simple explanations and plain calculations how an intake duct drawing air at atmospheric instead of room temperature lowers the average cost of compressed air.

It has often been observed that the output of an air compressor is greater in winter than in summer; that is, it seems that a machine which has had to "hustle" to furnish air in summer, may be able to maintain the required pressure at a reduced speed during the winter. The reason for this is often asked, so an explanation will be of interest.

This difference can be observed only when the compressor takes its air through a duct leading from the outside air, because it is due to the effect of the difference of air temperature between the compressor intake and the place where the air is used or conveyed through.

Imagine a cylinder having a perfectly tight piston held, we will say at midstroke, and the half-cylinder full of air at atmospheric pressure and at a temperature of 60 deg. F. The atmospheric pressure is, with 30-in. barometer, 14.7 lb. per sq.in. With the piston held rigidly and leak-tight, assume that we can heat the cylinder so that the air inside will become 100 deg. F. This will cause the air to expand and try to occupy more space, but if the piston will not move the air cannot expand, so it will increase in pressure. Mathematically, the pressure produced in this way will be

$$14.7 \times \frac{100 + 460}{60 + 460} = 14.7 \times \frac{560}{520} = 15.84 \textit{ lb. per sq.in.}$$

That is, the new pressure, absolute, will be equal to the first pressure, absolute, multiplied by the ratio of the absolute temperatures. (The absolute temperature is found by adding 460 to the Fahrenheit temperature, as done above.)

If, in the cylinder we are considering, the piston is allowed to move as the air expands and if it has no friction, so that the air pressure does not increase, the final volume will be larger than the original volume in the ratio of the absolute temperatures. If the original volume was, say 10 cu.ft., the final volume after the piston has moved due to increase of air temperature will be

$$10 \times \frac{100 + 460}{60 + 460} = 10 \times \frac{560}{520} = 10.77 \textit{ cu.ft.}$$

At the usual room temperatures (about 520 deg. F. absolute) the increase of volume is, roughly, 1 per cent. for every 5-deg. F. increase of temperature.

Let us see how the foregoing applies to a compressor plant. Irrespective of the outside temperature, the air in the shop pipe lines will be nearly at the temperature of the room by the time it reaches the tool. Suppose in winter this temperature averages 68 deg F. and that the air finally reaches the tool at this temperature. If the compressor takes in 1000 cu.ft. of free air (air at atmospheric temperature and pressure) directly from the room, it will also deliver 1000 cu.ft. of free air at the tool, because the final temperature is the same as that at which it entered the compressor.

In summer the same conditions apply as long as the compressor takes its air from the same room in which the compressed air is used; but if the compressor is provided with an intake duct leading from the outside air, the results will be quite different. First, consider the winter condition. Suppose the shop temperature averages 68 deg. F. and the outside air 30 deg. F. If the air is used at 68 deg., its volume will be considerably greater than the volume taken into the compressor from the outside air at 30 deg. If it requires 1000 cu.ft. of

free air per minute at shop temperature to run the tools, the compressor will have to take in only

$$1000 \times \frac{30 + 460}{68 + 460} = 1000 + \frac{490}{528} = 929 \; cu.ft.$$

which is a saving of over 7 per cent. in air capacity, speed and horsepower. In summer, when the outside temperature is practically the same as the temperature indoors, there would be no saving by using the intake duct, except, as is often the case, when the compressor takes its air supply directly from the hot engine room. Thus, it is seen that the compressor would run at a speed about 7 per cent. lower in winter than in summer. The colder the climate, the more pronounced this effect would become.

An actual case where the application of an intake duct to a compressor represented an appreciable saving recently came to the writer's attention. An air compressor furnishing an average of 2500 cu.ft. of free air per minute to a machine shop took its supply from the basement of the engine room, where all the year round the air, heated by a network of steam pipes, averaged 95 deg. F., while the shop averaged 70 deg. F. During the winter months the outside air averaged 32 deg. F., and in summer 70 deg.

Based upon the average consumption of 2500 cu.ft. per min. for 10 hr. a day, the air used amounted to an average of

$$2500 \times 60 \times 10 = 1{,}500{,}000 \; cu.ft.$$

per day at the shop end.

As the compressor-intake temperature averaged 95 deg. F., the compressor was obliged to run fast enough to take in

$$1{,}500{,}000 \times \frac{95 + 460}{70 + 460} = 1{,}500{,}000 \times \frac{555}{530}$$

$$= 1{,}570{,}500 \; cu.ft.$$

of engine-room air per day.

The cost of compressed air in this plant was found to be 2.8c. per 1000 cu.ft. at the compressor. Thus the cost of furnishing air to the shop was

$$\frac{1{,}570{,}500}{1000} \times 0.028 = \$43.97 \; per \; day$$

By putting in an intake duct and furnishing air to the compressor at 30 deg. F. in winter, the compressor could have run slower and would have had to take in only

$$1{,}500{,}000 \times \frac{30 + 460}{70 + 460} = 1{,}500{,}000 \times \frac{490}{530}$$

$$= 1{,}387{,}000 \; cu.ft. \; per \; day$$

At a cost of 2.8c. per 1000 cu.ft. at the compressor intake, the average cost of air for the plant during winter would then be

$$\frac{1{,}387{,}000}{1000} \times 0.028 = \$38.84 \; per \; day$$

During the summer, when the outside and inside temperatures both averaged 70 deg. F., the compressor would take in only the amount used in the shop, or 1,500,000 cu.ft., which at the cost of 2.8c. per 1000 cu.ft. at compressor intake would be

$$\frac{1{,}500{,}000}{1000} \times 0.028 = \$42 \; per \; day$$

With the intake duct in use we then have a daily cost for air of $38.84 for winter and $42 for summer. The average for the year may then be taken at $40.42 per day, as against $43.96 with the compressor taking air from the engine-room basement.

During a working year of 300 days, the annual cost for air would then compare:

Without intake duct	$43.96 × 300 =	$13,188
With intake duct	40.42 × 300 =	12,126
Giving a net saving with the duct of		$1,062

Capitalized at 10 per cent., this would justify installing an intake duct costing $10,620. As this figure approaches more nearly the cost of the compressor than it does the cost of the duct, the conclusion is obvious.

Incidentally, the saving of $1062 per year amounts to more than 8 per cent. of the yearly cost for air. It certainly looks worth while to install an air-intake duct under such conditions.

The Planetary Motion

The planetary motion devised and used by Watt to convert reciprocating into rotary motion is of interest, first because it was brought into use to circumvent a patent previously obtained by Wasborough on the simple crank for the same purpose. The other interesting feature is a condition where two gear wheels of the same diameter engage, but one makes two revolutions for each one revolution of the other. This may be easily tried out, or demonstrated, by using two coins with the edges sharply milled. Hold one of them stationary with the head up, or stick it fast with a little mucilage. Place the other with the head up directly in a vertical line above the head of the first. Now rotate the upper coin to the right around the fixed coin. It will be seen that by the time the former has reached the half revolution or the point directly below the fixed coin it will have turned one complete revolution, standing head up again. Another complete revolution will be accomplished by the time it reaches its original position. It will therefore have made two complete revolutions while engaged with a stationary coin of the same size.

It is obvious then, that if the coin being rotated were held head up all the way around, and the other coin made to rotate as on its center the latter would have to make two complete revolutions by the time the two coins had reached their original relative positions. One revolution is due to the crank motion and the other, to tooth engagement. This is proved by using a traveling gear twice the circumference of the shaft gear, which will produce a 3 to 1 ratio by reason of doubling the larger gear, instead of what might be expected—a 4 to 1.

Examples of the modern application of the planetary gear in the opposite way may be found in some geared chain hoists and also in some automobile transmission gears for slow speed.

Lloyds Safety-Valve Rules require that two safety valves be fitted to each boiler, the combined area of which shall equal at least ½ sq.in. for each square foot of grate area and the accumulation of pressure shall not exceed 10 per cent. of the working pressure. Each valve is to be so made that no extra load can be put on while under steam pressure.

Editorials

Michigan Is in Line

Michigan made a gallant fight for the adoption of the boiler code of the American Society of Mechanical Engineers during the session of the legislature recently closed. A bill (Senate Bill No. 234, File No. 299) provided for the appointment of a board of boiler rules to formulate rules as near in conformity with the A. S. M. E. code as possible. It passed the Senate without a dissenting vote. The bill was then referred to the Committee on State Affairs in the House and two hearings were granted, but those in charge of the bill were unable to secure the reporting of it out of the committee. The belief is general that if this bill had been reported out it would have been enacted into law with little opposition.

It is believed that at the next session of the legislature the A. S. M. E. code will be adopted by the state and a system of license regulations put in force.

It was discovered during the fight for the passage of this bill that opposition on the part of the thresher engine interests and the threshermen's organizations is weakening and coming to a realization that modern boiler practice and means for public safety must prevail and are a good investment.

This is the first time in the history of Michigan that a bill relating to boiler matters or engineers has passed either house of the legislature without a dissenting vote.

Michigan is in line. Let her move up to the window and receive her code.

The National Electrical Safety Code

The two principal sources of hazard to life around a power plant are the boilers and the electrical equipment, particularly where high voltages are employed. Just as safety in the boiler room depends upon the construction of the boilers and their intelligent operation, that in the electrical end of the station depends upon the proper installation of the electrical equipment and the care in handling it. The excellent work of the Boiler Code Committee of the American Society of Mechanical Engineers in preparing its recent boiler code, has been emulated by the Bureau of Standards, which has been at work for nearly two years on an electrical safety code. It is particularly fitting that this work should have been undertaken by this bureau, devoted in its scope to scientific and engineering problems and in a position to approach the subject with an open mind. While the bureau has employed experts especially for this work, it has in no way attempted to force its own opinions on the public, but instead has endeavored to learn the views of various electrical companies and, through conferences and sifting of these views, to arrive at a set of rules which will represent the best practice.

The rules are divided into four parts, the first three dealing respectively with the installation and maintenance of electrical supply stations and equipment, electrical supply and signal lines, and electrical utilization equipment; the fourth covers rules for the operation of electrical equipment as concerns both the employer and the employee. Part 4,* which is printed as a separate bulletin, was first published last August in a tentative form and was widely circulated for comment and criticism. It has now been revised in accordance with a number of suggestions and, in conjunction with Parts 1, 2 and 3, is being circulated for further criticism before final revision.

Lack of space prevents our reprinting the rules, but we would urge those readers who are interested to obtain copies from the Superintendent of Documents at Washington, and send in such suggestions as may seem advisable.

While the Bureau of Standards has no direct power to enforce the observance of such rules, it is believed that most electrical companies and even private plants will find it advantageous to adopt them. Moreover, it will form a set of uniform rules, which public-service commissions or municipalities may find it convenient to enforce.

Taking Charge of a Larger Plant

To "make good" in the new sphere of duty is the honest ambition of every right-minded engineer who is promoted to larger responsibilities. Not always, however, does he find his hopes realized under the changed conditions. Failure to do so may be due to many causes.

Causes beyond the engineer's control cannot be helped. Vicissitudes such as the collapse of a factory business through changed economic conditions, the sale of an industrial plant by the owners to others who prefer to discontinue power production locally because of representation on central-station directorates, or the maladministration of a property through nepotism will discourage any but the trained operator, who knows that in the long run there is sure to be a market for his services. It is more important to consider those factors in service over which the engineer may maintain mastery—those policies which lead to success when properly directed and applied in the new field of usefulness.

On taking over a larger installation the temptation arises to emphasize the weak spots left by one's predecessor and to make a clean sweep of methods which at first appear open to criticism. It is wiser to make haste slowly. The sharpest possible analysis is commendable, but little is lost by taking sufficient time to get one's bearings.

No installation looks the same from within as it does from the outside, and to make a brief inspection of a plant as a possible chief engineer, and then later to go over the installation as its responsible executive are two very different things. No two plants are exactly alike, and even if similar in makeup, will not run in exactly

*See "Power," Dec. 8, 1914.

the same way. The engineer who takes time to learn the personal abilities of his new subordinates and the strong and the weak features of the equipment, individually and collectively, is wise. Let him avoid attempting to reform the whole institution the first week, and by the second or third week he may find it possible to begin to effect some real economies through the coöperation of those under him. While a glaring instance of preventable waste should not be allowed to continue even for a week, it pays to let the old staff discover that the new chief is willing to learn, that he is glad to receive the help of those more familiar than he with the local equipment and load situation, and that he is determined not to act on snap judgment to impress the "boss" with his instant ability to cut costs and make a new record.

An exceptional man may take over a new job of this kind and almost immediately inaugurate an efficiency policy which revolutionizes practice within the station. Such an overturn may be accompanied by a substantial crop of recommendations for discharge, without waiting to find out if the men most familiar with the routine work cannot gradually be brought to work in harmony with the new program. It takes time to find out what those already on the ground can do, and a plant may fail to do its best work for many reasons other than incompetency of the force. It is nearly as important for a new chief engineer promoted from within to introduce his executive ideas moderately. Where a subordinate engineer is not available to promote, the new chief needs insight and tact to get the best from his predecessor's force.

A contented staff has more to do with economical operation than some realize, and whether an engineer takes charge from within or from without, a probationary receptive period is an effectual means of getting acclimated to his new responsibilities.

Recognizing Abnormal Conditions

The ability promptly to detect abnormal conditions in plant operation is most valuable to the engineer. Nothing so clearly denotes the expert as immediate appreciation of the existence and cause of any unusual sound. The same is true with respect to scrutiny of the log sheet and to the study of test data.

While many sources of inefficient operation are soundless, cultivation of a keen sense of hearing is worth much to the engineer. With high-speed machinery, even very slight departures from the normal tend to become magnified. Every plant has in a measure its own sound characteristics, due to the sort of load it carries and to the peculiar combinations and sizes of main and auxiliary units in service. From long experience most engineers will sense abnormalities in sound almost subconsciously, but a new man will need to make a special effort to develop this faculty as quickly as possible. Things happen pretty fast when an unusual condition becomes cumulative, with modern turbine and high-powered auxiliary equipment; the value of machinery under the control of the engineer today runs to figures far in excess of a decade ago; and the ability to see ahead and to catch the drift of sounds which the untrained visitor would never notice is very important.

When examining operating and test records, a similar skill in instantly "spotting" departures from the normal is of great advantage. It takes practice to scan tabular data rapidly without losing their significance. The starting point is to know what to expect in a routine way, and this can be acquired by continued study and observation. Roughly, each plant may be said to have a set of "constants" of its own. That is, the temperature of the feed water will run between such and such limits when every day's record of coal consumption per kilowatt hour keeps down to the average minimum consistent with the local conditions; the variations in steam will follow a well-defined cycle, if this is varied purposely, or will hold close to a predetermined zone above and below a fixed average so long as things go as they should. Seasonal variations will be noted in the temperature of intake and discharge water.

It is the engineer's task to maintain normal conditions of service and instruments help in this work, but perhaps too much reliance is placed on automatic charts at times. The really professional understanding of one's plant is the kind that combines the keen ear and the microscopic eye with a continuous apprehension of a considerable number of physical data which set a standard for every departure from efficient operation. In other words, when the readings of instruments depart from the normal by a certain differential, when test sheets contain figures that jump out of the routine range for a little while, the expert engineer notes them at once and if possible acts promptly and reduces preventable losses.

Intense personal interest in an installation leads to skill in diagnosing the approach of abnormal conditions through knowledge of what seem trifles to the man of mediocre ability or to the layman. The result is a reduced maintenance expenditure and a better record for service continuity, to say nothing of an almost inevitable improvement in operating economy.

The Federal Government inspects the locomotive which draws your train, and no steamer can carry passengers without a certificate from the Federal inspector that its boilers have been inspected and its engineers examined and found safe and competent. The Federal Government also requires the stationary boilers in the District of Columbia to be inspected and requires a competent attendant for them, but only four out of forty state governments are equally solicitous for the safety of their citizens. The people are protected when they travel, because the Federal Government can do it, but not when they stay at home, because the state government will not.

The troubles of the engineer are many and sometimes unique. One of our good friends up along the Hudson River finds so much moisture in the air used for forced draft that in winter ice accumulates on the under side of the grate. Sometimes, especially when the fire is about four hours old, ice so plugs the air spaces in the grate that it becomes necessary to put a steam hose in the ash-pit and melt it so as to pass enough air to keep up the required rate of combustion.

Our contemporary, *The Electrical Review* of London, "cannot approve of all methods adopted by American consuls" in stimulating trade activity with France. Why should they?

Correspondence

Gas Explosions in Boiler Furnaces

In your issue of Apr. 20 I read the interesting communication by L. A. De Blois, concerning a gas explosion in a boiler furnace. The three correspondents appear to be at a loss to explain the formation of an explosive mixture, or, in other words, the entrance of a sufficient amount of air into the formed carbon monoxide under the condition described; that is, with the fire-door closed, the tuyeres blocked by a clinker and the damper wide open. It seems to me that the formation of an explosive mixture under these conditions is a very natural occurrence.

Carbon monoxide is somewhat lighter than air, and on account of the higher temperature in this case it is considerably lighter than the outside air. The open stack with the closed furnace, therefore, represents a vessel having a lighter fluid at the bottom and a heavier one on the top. These two fluids, if not in motion, are in unstable equilibrium, and it is only natural that a slow flow of the lighter gas toward the top on one side of the stack and a corresponding return flow of the heavier air on the other side of the stack would take place. I believe that the sketch will make this clear.

The moment the fireman broke off the clinker and thereby opened the discharge from the fan, rapid combustion was started, with a consequent development of high temperature, probably projecting a flame into the combustible mixture. This started the explosion because the time intervening between the opening of the fire-door and the breaking off of the clinker was not sufficient to remove this explosive mixture from the furnace.

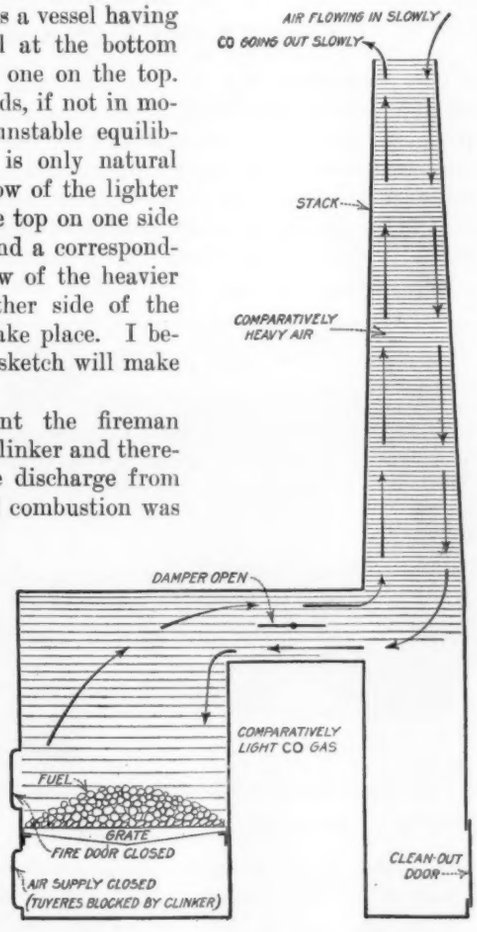


FIG. 1. HOW AIR MAY HAVE ENTERED FURNACE AND CAUSED EXPLOSION

It seems to me that a reliable arrangement for preventing this occurrence could be made. If the conditions of the furnace, its operation and the fuel used are such as to permit a constant admission of a small amount of air above the fire, an opening should be provided in the fire-door and it should be made impossible to close this opening. In this case, even if the tuyeres were completely blocked, the constant, if slight, draft would remove any carbon monoxide that might be formed.

If, however, the existing conditions do not permit this sort of an arrangement without destroying the efficient operation of the furnace, a bypass may be provided in the air supply, branching off between the blower and the tuyeres and entering the furnace above the fire. This bypass should have in it an unbalanced damper which is normally closed but which opens when the pressure in the air-supply pipe rises on account of the tuyeres being stopped up. This damper (or virtually, check valve) could easily be provided with an indicator on the outside by which the fireman's attention would be called to the fact that the tuyeres have become clogged (see Fig. 2).

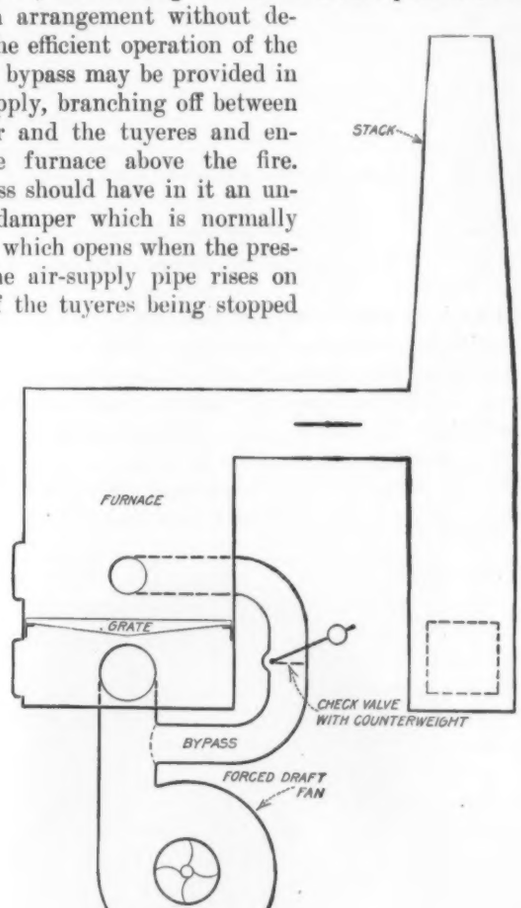


FIG. 2. BYPASS AROUND GRATE

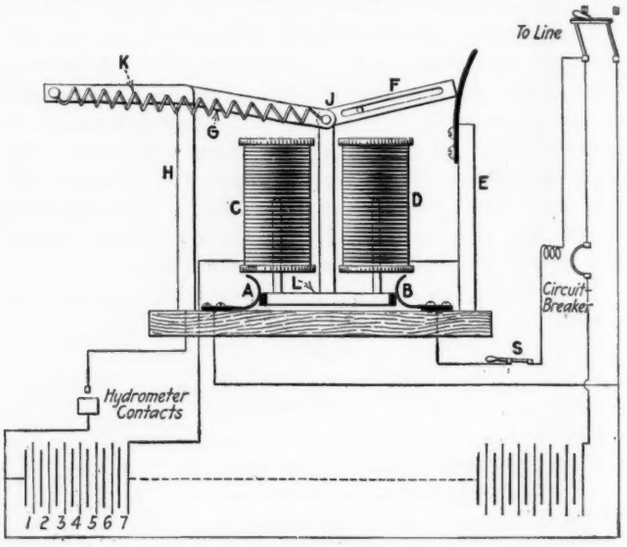
This analysis is based only on the information which I can gather from the communications as I found them in POWER. Should my understanding of the case be incorrect, I would appreciate a word from Mr. De Blois, to clear the situation in my mind.

ROBERT CRAMER.

Chicago, Ill.

Low-Gravity Cutout for Storage Battery

The battery in question was rated at 50 amp. at an 8-hr. rate and supplied current for lighting and for a few small motors from 6 p.m. until 7 a.m. It had been badly overloaded at times, and despite repeated warnings



WIRING OF AUTOMATIC CUTOUT

to various people around the institution, the overloads would recur all too frequently. Finally, it was decided that something more effective than warnings was necessary. After considering various plans, it was decided to install a circuit-breaker which would be tripped when the recording hydrometer dropped to a certain point. This hydrometer was already equipped with a contact on the pen arm, which dipped into an adjustable mercury cup, so that this part of the job was very simple. It was necessary to construct a relay to close the trip coil circuit and install a circuit-breaker. The sketch shows the relay and wiring diagram.

When the hydrometer reaches the lowest point desirable, it closes the circuit through solenoids *C* and *D* and part of the battery. It was best that this circuit should be broken as soon as it had accomplished its purpose so as not to further drain the cells. This was provided for as follows:

Current passes from cell No. 7 to coils *C* and *D*, thence to post *E* and the flat spring attached to it, through *F* and *G* and down post *H*, via the hydrometer to cell No. 1. As soon as current flows, *C* and *D* are energized and *L* is lifted and also the rod which is attached to it. This throws the joint *J* upward, and the coiled spring pulls it back, drawing *F* out of contact with *E* and breaking the circuit. Once *L* has been pulled up, it cannot fall, because the spring contacts *A* and *B* are so formed and adjusted as to prevent it. As soon as *L* bridges *A* and *B*, line current flows through the coil of the circuit-breaker and trips that device, thus opening the battery circuit.

If anyone should gain entrance to the engine room and attempt to reset the breaker, the latter would immediately open again, because by the closing of the breaker its trip coil would again be energized. Furthermore, as the relay is under lock and key, no one could reset it except the engineer having the key.

It remains to relate that the principal offender was the first to be caught. When he had carelessly pulled the battery down and the circuit-breaker had opened, he found himself in inky darkness.

WILLIAM E. DIXON.

Cambridge, Mass.

Crankpin Failure

The photograph, Fig. 1, is of a crankpin that failed recently on one of our 24x36 first-motion hoisting engines. When the pin failed both guides broke, the rear cylinder head was broken out by the piston, and the piston and piston rod were ruined. The engineer shut the throttle the instant the accident happened and threw on the brake, thus stopping the cages where they were and preventing a more serious damage. Fig. 2 gives the dimensions of the pin and shows where the break occurred. This sort of failure is what is called a fracture in detail.

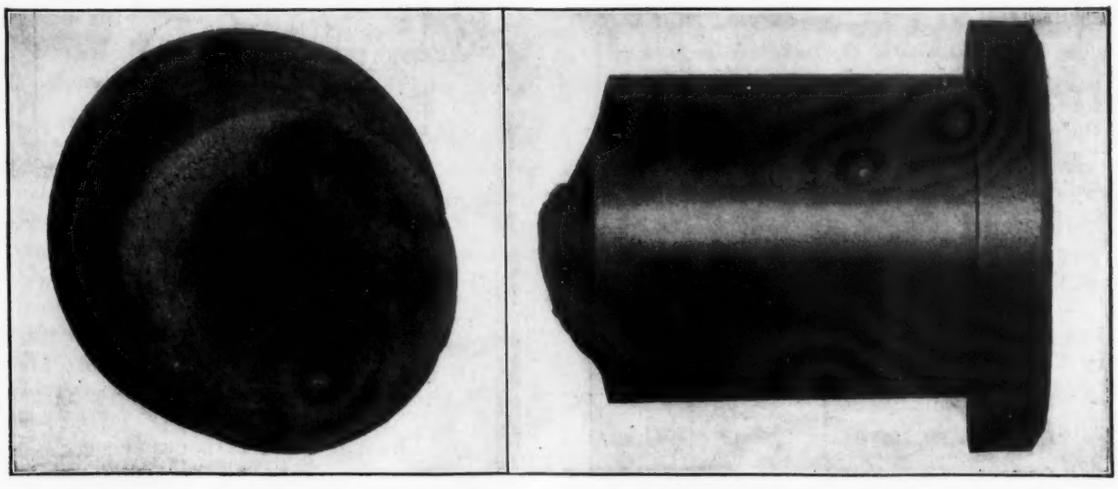


FIG. 1. TWO VIEWS OF BROKEN CRANKPIN

It was not due to any flaw in the material, nor does it seem possible that the pin was too small. The maximum steam pressure carried is 120 lb., and with this pressure on the 24-in. piston the total load on the pin would be less than 55,000 lb. The 4½-in. pin, the cross-sectional area of which is $15\frac{7}{10}$ sq.in., should be large enough to carry the load with a large factor of safety. Of course, if there was any slack rope the starting load would be

greatly increased, but the ropes are always kept closely adjusted. No doubt the trouble was due to a fault in the design of the pin. It will be seen that the corners on both sides of the 7/8-in. collar next to the crank disk are perfectly sharp, with no fillets whatever. These were the weak points at which the fracture could start. The 7/8-in. collar mentioned was a part of the crankpin. Probably it would have been better if this had been a

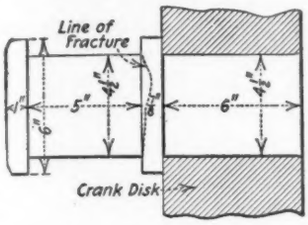


FIG. 2. ORIGINAL DESIGN, FAILED

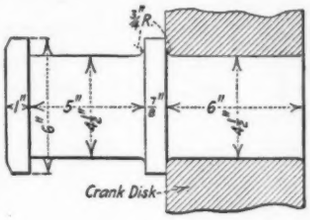


FIG. 3. NEW DESIGN

separate collar shrunk on at the proper place, thereby eliminating the sharp corners. We have three hoists of the same size in service, and considerable trouble has been experienced in the past with crankpin failures. Occasionally, the wrecks have been rather serious. More than once the whole cylinder was wrecked and had to be replaced. Various grades of steel pins have been experimented with, but the results were practically the same. So it was decided to change the design of the pin. Fig. 3 *B* shows the new design adopted. It is thought that the 3/4-in. radius fillets on each side of the collar will stop the trouble. However, these new pins have not been in service long enough to prove anything yet.

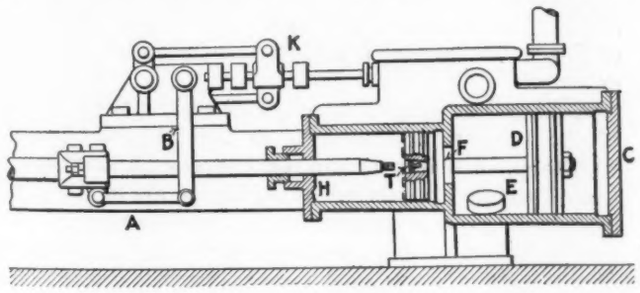
I would like to know whether any of the readers of POWER have had similar experiences, and if so what steps they have taken to remedy the trouble.

F. F. JORGENSEN.

Gillespie, Ill.

Pump Would Not Run

When a duplex tandem compound pump failed to start it was at first thought that the steam valve had shifted, but links *A* were disconnected and the valves operated by lever *B*. One side of the pump made full strokes,



CONDITIONS INSIDE OF PUMP

but the other side moved only a few inches in the center of its travel and struck something solid.

Head *C* and the low-pressure piston *D* were removed, and in the bottom of the cylinder was found the nut from the end of the high-pressure rod, and the large disk *E* which screws in the center of the wall *F* between the two cylinders.

Head *H* was removed and it was found that a follower bolt *T* had dropped out of the high-pressure piston and had worn the cylinder head about half through, at *H*. This bolt was found wedged in the hole in the center of the high-pressure piston, as shown. The bolt *T* was taken out, the high-pressure piston put back on the rod, and the large plug *E* put into its place. The cylinder head *C* was put on, but piston *D* was left out, and by readjusting the spools at *K* the pump ran very satisfactorily until a new piston could be secured.

ALBERT CARPENTER.

Adams, Mass.

Lubrication

Your Mar. 23 editorial, subject "Lubrication," suggests a few comments. Modern equipment such as high-pressure compound condensing reciprocating engines, turbines, and Diesel, producer gas, locomobile and uniflow engines, air compressors of several stages, also eight- and twelve-cylinder automobile engines, require the best oil obtainable; any other kind retards smooth operation. Some engineers admit that their engines are better judges of good oil than they are.

The present standard of oil analysis needs revision. Oils varying in chemistry and physical properties materially render selection difficult. Few buyers are able to differentiate between the good and the bad. The Independent Petroleum Marketers' Association, recognizing this deficiency, selected a committee of experts about two years ago to investigate this situation, but so far no report has been made, nor has any new standard been adopted.

Most of the crude oil produced in this country, or about 76 per cent., is of asphaltic base and of low market price. The other 24 per cent. is of paraffin base, ranking very high; in some instances a premium is paid for it. It is the difference between the two that puzzles many engineers. To them the finished oils look alike, whether Eastern or Western products, but when the asphaltic-base oil is used under high-pressure modern conditions, the asphalt condenses at its critical temperature. This deposit may be found in cylinders, packing rings and piston rods, accumulating until sheared off. It causes engines to labor hard, calling for increased oil supply and also finds its way into condensers, reducing their efficiency. Asphalt has no lubricating value and should be abandoned when trouble presents itself.

The paraffin-base oil, mainly from Pennsylvania, has the reputation of being the most reliable oil found anywhere. It is becoming scarcer every year. During 1914 the production in Pennsylvania fell off 963,282 bbl. If the same ratio continues, in about eight years it will cease.

The widely used red engine oil, being of an asphalt base, wears rapidly. It disintegrates after being fed to the bearings a few times and causes abrasion. Next, an imperceptible wear of the metallic rubbing surfaces begins and the oil finally finds its way into the filters, dirty, with its lubricating value reduced until it is gradually worn out. In a short time another barrel must be ordered. Its ultimate cost is high. Buyers may recognize herein why they find it necessary to order oil so frequently. The remedy is to install an outfit which returns the used oil to a filter, and adopt a bright-yellow, good oil (not acid-treated) which may be fed by drops, or in a stream in

hot weather. Such an oil wears longer and needs little replenishing and that at longer intervals. Its ultimate cost is low.

Under any given conditions the oil which results in the lowest cost, owing to consumption, cost of coal needed to overcome frictional resistance, and cost of repairs due to metallic wear on metallic journals and brasses, is the best.

A modern high-pressure compound condensing engine requires the best oil obtainable. Such oil cannot be bought at a low price. But it may be the cheapest in the long run. Dependability, long service and ultimate cost are the determining factors. When engines labor and groan and valve and eccentric rods vibrate, or traces of asphalt appear, an immediate change of oil is advisable. Soft spots may appear in cylinders, causing wear, or leaky throttle valves, causing corrosion when the engines are idle. Or the trouble may be due to stale, rancid animal oil used in animal-oil compounds, coming in contact with hot steam and decomposing, forming acids. This causes soft spots, and if not remedied will result seriously. No reputable oil company will use rancid animal oil, or rancid wool fat or De Gras, which may be detected by its odor. Animal oil for compounding should be sweet and fresh and preserved in refrigerators when the temperature is above 50 deg. F.

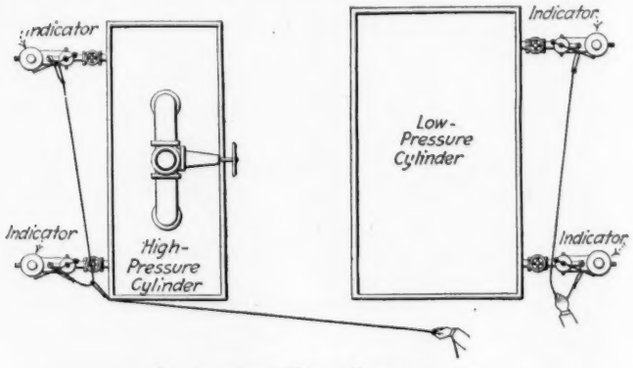
The writer's method of handling lubrication problems is to diagnose each case by itself. With practiced eye and well-trained ear the remedy is simple. In general, the modern uptodate little-drop method of cylinder lubrication supplied by a mechanical lubricator operated from the valve movement, when accompanied by a good oil, results in perfect lubrication, requiring the smallest consumption, at the lowest ultimate cost.

JOSEPH W. FROMEYER.

St. Louis, Mo.

Taking Two or More Diagrams Simultaneously

Taking diagrams simultaneously is essential for the purpose of accurately determining the horsepower developed, and also for valve setting. Sometimes it is neither convenient nor possible to make use of the magnet attach-



OPERATING FOUR INDICATORS

ments in handling two or more indicators. In using magnets dry batteries and wiring connections must be provided. The magnets must be delicately adjusted in order to make the proper pencil mark, and considerable time and trouble are entailed in making such adjustments. In lieu of magnets the following method may be adopted:

At each end of a cord about two feet longer than the distance between the indicator cocks make a loop about six inches in length so that there will be no knots to interfere, pass the loop over the pencil arm, which has been previously provided with an elastic band to hold the pencil off when not indicating. We now have a flexible connection to both indicators, and a pull on the cord will take as many diagrams as desired.

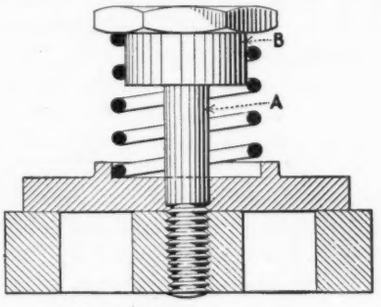
When indicating a cross-compound engine a third cord may be looped about the cord on one cylinder or the latter may be of sufficient length to reach the other cylinder where the operator can control all four indicators simultaneously. I have found this method simple and convenient.

L. L. LOOMER.

Waterbury, Conn.

Repairing Pump-Valve Studs

This will help out if your stock has run out and the pump valves have to be repaired before new studs can be obtained. Cut off the old valve stem and use the top part *B* as a nut after it has been drilled and tapped, then



HEAD USED AS A NUT

take a bolt or brass rod and make a stud *A*. This will answer the purpose as well as a new one. The nut may be pinned or riveted on if necessary.

JOHN M. RUPPERT.

Philadelphia, Penn.

Condensation from Water-wheel Casing

Waterwheels expose to the air a large surface which sweats under certain atmospheric conditions. Disposing of this water becomes a troublesome job to the operating engineer.

A channel or flange is usually cast around the periphery of the sub-base and drained to the tailrace. On the 20,000-hp. units in a certain plant several hundred square feet of surface are exposed to the heated air of the power house and the condensation is copious. During the first months much of the operator's time was taken up in disposing of the condensation collecting in the drainage channel, as the operating conditions made it inadvisable to utilize the customary drainage tubes.

The wheel, revolving rapidly in the closed casing, always produces a considerable vacuum at the shaft. This vacuum was utilized through a ⅜-in. pipe tapped into the casing, fitted with a valve, and extended to the drainage channel to remove the water.

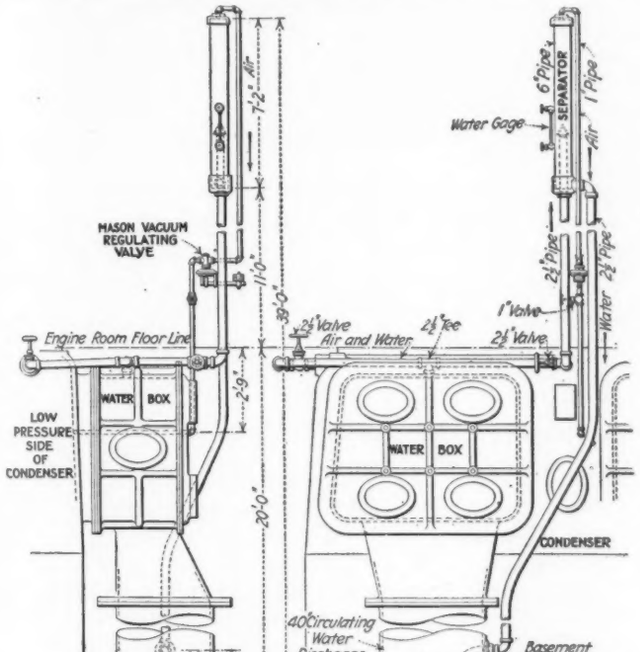
WALTER SWAREN.

Hayward, Cal.

Removing Air from Condensers

At the steam station serving the Twin City Lines we have five Curtis turbines of the vertical type, equipped with Worthington three-pass condensers. A great deal of trouble was caused by the accumulation of air, especially in the water box at the end of the last pass. The top of this box is about twenty-four feet above the level of the water in the river, both the intake and discharge pipes being submerged, making a sealed system.

Various devices were tried to remove the air, among them the plan of tapping the top of the box and connecting to the condenser, the pipe being fitted with a globe valve which was opened and closed by hand. The objection to this scheme was that, if the valve was opened too wide, too much water would be taken over into the



AIR RECEIVER AND PIPE CONNECTIONS TO CONDENSER

condenser. We tried to overcome this by extending the pipe in the form of a loop ∩, the upper part being about forty feet above the river level, but we found that the water would go over in "slugs". We then decided on placing a separator in the uptake side of the loop, and one was made up of 6-in. pipe and fittings approximately the same as shown in the accompanying illustration. Later, we applied the Mason vacuum regulator and have found the 1-in. regulator, with a pipe of the same size, large enough to handle all the air.

"Slugs" of air and water pass up the 2½-in. pipe into the separator through the short piece of pipe shown by dotted lines, the water separates from the air and flows out through the discharge pipe into the circulating discharge. By means of the weights on the lever of the regulator it is possible to obtain any desired vacuum in the separator.

We have found that this device gives excellent satisfaction, and when once adjusted, it needs no further attention on the part of the engineer.

GEO. W. CAYWOOD.

Minneapolis, Minn.

Engineers' Salesmanship

Some time ago there was an editorial in POWER on this subject, and it may not be too soon to bring it up again. At that time it was stated that the engineer applying for a position as salesman is handicapped through lack of actual selling experience and because he has no past record of sales ability. The questions now arise: What is sales ability? What qualities must the successful salesman possess?

In order to approach a business man at all it is necessary that one be neat in personal appearance; then, when one gets to his man, one must have a fair command of English and a pleasant disposition to start a conversation and, once the conversation is started, self-confidence in the line and oneself, together with a thorough knowledge of the specialty offered for sale, to maintain the conversation until the goods offered have been shown up at their best. There is such a thing as saying too much in some cases; therefore, tact and a knowledge of human nature are also required.

The qualities mentioned are the principal ones that go into the makeup of a successful salesman. What has the practical engineer to offer his prospective employer in the sales game? The engineer, to be successful in even a fair-sized plant, must have all the qualities mentioned above, with a few more thrown in. He must be tactful, to keep his crew working smoothly; he must be neat about himself and the plant; he must have an agreeable nature, to keep peace with his employer and the tenants in the building; he must have a thorough knowledge, not of one, but of a dozen and one different appliances to keep his plant going; and he must possess facts and figures and know how to present them when he and the central-station man meet on the mat in the manager's office.

The engineer, therefore, can offer the manufacturer of steam specialties the same qualities that the salesman can, plus practical experience, which more than offsets the lack of actual selling experience in the beginning.

The manufacturer should bear in mind a few proved facts. Many a perfectly dependable piece of apparatus has been returned to the makers and condemned because it failed to do what it was sold to do. Why? Because it was installed under conditions where it could not operate efficiently, or otherwise. It was sold by a man who was only a salesman and did not know whether it would operate. A practical engineer would have made no such mistake; he would know from experience that only failure could result.

It is to the interest of the manufacturer, not only that an appliance should operate, but that it should operate at maximum efficiency. Repeat orders are the life of a concern, and a good piece of apparatus will fail unless properly installed.

Last, but not least, while the engineer is not always the buyer he can always be the knocker. An engineer salesman can walk into a plant, and being an ex-engineer, he usually has no trouble making a friend of the average engineer. He sees things about the plant an ordinary salesman would not notice and can probably make suggestions which will lead to a sale. He asks questions the average man would not think of and gets information which the ordinary salesman could not obtain. If there is a complaint about anything he usually gets it first, and thus has the opportunity of correcting the fault before

it goes further and causes unpleasant business relations. While going about he can collect trade data at little or no cost; data which usually cost the manufacturer quite a little to secure through other sources.

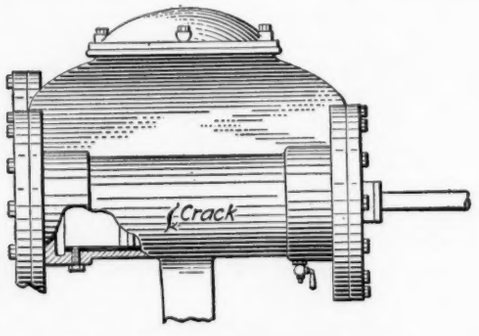
The average buyer of today appears to hail from the corn-cob state; he must be shown, and who is better qualified to show him than the man who can get into a pair of overalls and install and operate his plant? All engineers will not make good salesmen, but in view of what is required of the modern engineer one can safely say that a larger percentage of men who can qualify for salesmanship in the engineering field can be taken from the ranks of the operating man than from any other body of men.

A. H. Pohlman.

Brooklyn, N. Y.

Emergency Pump Repair

In the plant where I am employed a small vacuum pump on the returns from the heating system developed a crack about three inches long in the cast-iron cylinder of the water end. When we overhauled it we found that the crack did not extend through the brass lining and that



Plug Extended into Lining

the water got in between the iron and brass at the drip opening. We screwed a brass plug into the drip opening flush with the bore and smoothed it up nicely. On starting the pump the crack did not leak a bit and had closed up somewhat.

I think the pressure between the lining and the cylinder forced the crack open, as at times it has to work very hard.

Howard H. Whitaker.

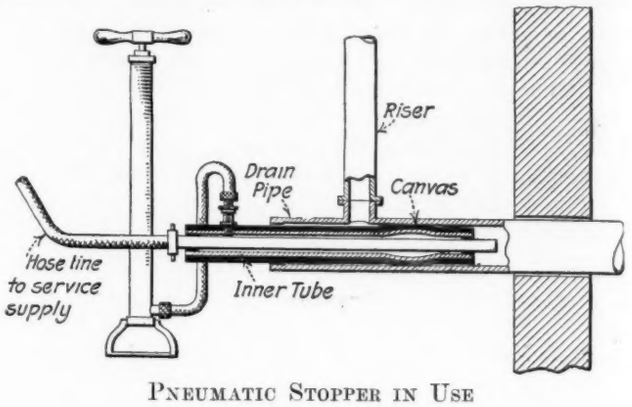
West Somerville, Mass.

A Pneumatic Pipe Stopper

Difficulties are encountered at times in clearing out obstructed drain pipes on account of abrupt turns in the piping, which a steel "snake" or its equivalent is unable to pass around, and it is necessary to use a hose connected to the hydrant pressure to clear the obstruction.

If, however, a plug is removed and a hose connection made, the water, instead of passing through the obstructed piping, will ascend in risers and overflow from the sinks or washbowls above. A case of this kind recently came within the writer's personal experience. The 3-in. drain pipe, with a 2-in. screw plug in the end, passed through a basement wall. About 12 in. from the end of the pipe a 2-in. riser extended to the floor above.

To make a water-tight connection with the drain pipe and prevent backflow in the riser, the device shown was made up in a few minutes from material that happened to be at hand. A 2-ft. piece of a bicycle inner tube, having the valve attached, was cut off and slipped over a ¾-in. iron pipe and bound tightly at each end by winding stout cord about it and the pipe. Over this a piece of



Pneumatic Stopper in Use

3-in. cotton hose was placed and bound in like manner. A line of hose was attached to the service supply and connected to the ¾-in. pipe, and the end was inserted in the drain pipe as shown and the tube inflated with a foot pump, which produced a water-tight coupling.

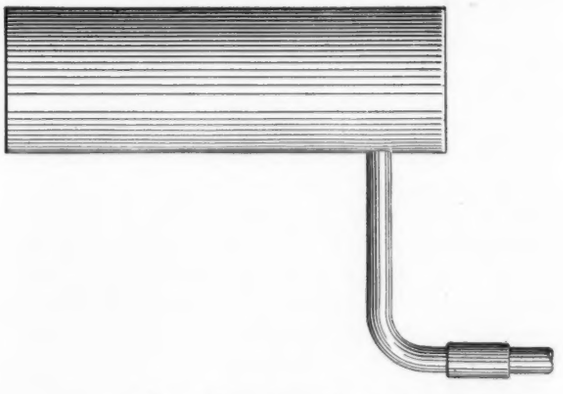
T. H. Reardon.

Pittsfield, Mass.

Blowoff Piping

The company for which I am working built a new plant a year ago, and the blowoff piping was something novel to me, although it may not be to all readers of Power.

The engineer who has had to go into a hot combustion chamber and install a new blowoff pipe after an elbow has failed will appreciate this arrangement, as it does away with a threaded elbow. The pipe should be extra heavy,



Bent Pipe for Blowoff

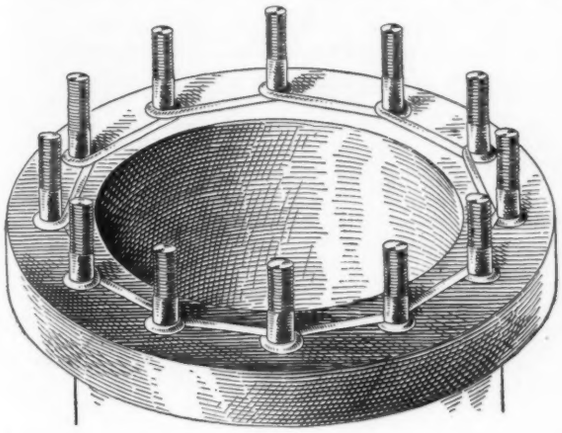
and will be better if made of wrought iron, which is easily bent. This leaves a clear passage for scale and sediment in blowing off the boilers, and if properly protected, I see no reason why it should not last for years; it will certainly reduce the danger from water-hammer and elbow failure. The company furnishing this equipment always uses a bend instead of an elbow, wherever possible.

T. A. Epply.

Thomasville, Ga.

An Emergency Gasket

The writer has used a gasket for a steam main, made as shown in the illustration. Long pieces of lead rope were inserted between the pipe flanges and wound around the bolts. A mixture of red lead and linseed oil was then added, the whole being flattened and spread out by



LEAD ROPE AS A GASKET

the strain on the bolts. This form of gasket may be tightened as required from time to time, taking care that the lead does not spread too much and project into the bore of the pipe.

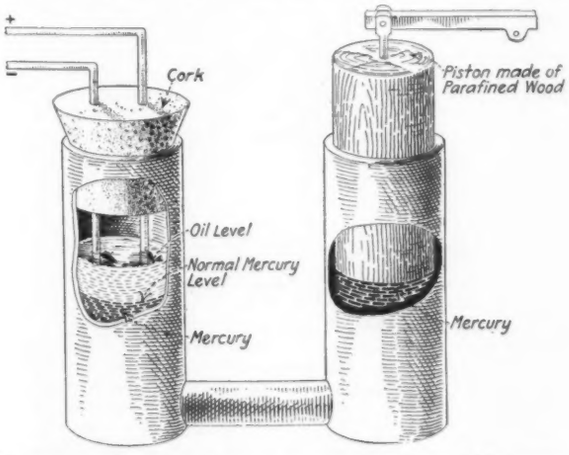
T. W. REYNOLDS.

New York City.

Signal-Circuit Make-and-Break

Use a U-tube of glass or iron pipe, into which the wires should be fastened by pushing through a cork and varnishing, or, if the tube be of glass, they may be fused in place. The tube should then be filled with mercury to a point slightly below the ends of the wires and enough oil put on it to cover the tips of the wires.

The loosely fitting piston is to be placed in the other



ELECTRIC CIRCUIT COMPLETED BY RISE OF MERCURY

side of the tube and so connected to the float or mechanism that is to operate it, that it will be depressed and displace enough mercury to cause the column to rise in the opposite side and close the circuit by submerging the points of the wires. This will be accomplished away from the air and under oil, and may be used with safety around gas or other explosives.

This device does not require attention, as the oil cannot "creep out." It can be made as acid- and fumeproof as the electric conductors themselves, and also "foolproof."

H. KING.

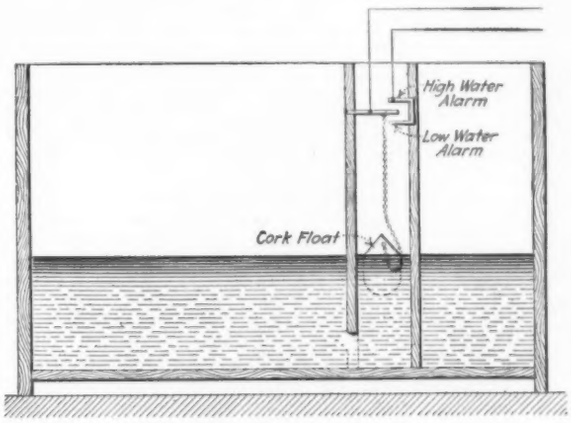
Wilkinsburg, Penn.

Tank Float and Alarm

The illustration shows a high- and low-water alarm for a tank, which we developed after considerable experimenting.

The situation was more difficult than usually met with, on account of the water being supplied to the tank by two pumps discharging at opposite ends of the tank, the agitation causing waves which kept the float and switch in almost constant motion.

A casing open at the bottom was fastened inside of the tank in which the float was placed, and after this the



FLOAT INSIDE OF CASING

surface agitation had little effect. The rising and lowering of this cork float opens and closes the electric circuit which rings the alarm bell in the engine room. The float fits in the casing so as not to turn over, and the light chain allows considerable variation in the water level before the alarm sounds.

IRVING COBB.

Atlantic City, N. J.

A Broom Handle in the Cold-Water Pipe

A water-heating plant gave off various noises and our steam fitter was called to remedy it, and I was invited to go along. The heater was in the basement, and as we entered, the pipes gave off a continual chatter, then got quiet for a time, and then jerked in a way likely to tear the piping out.

At first we thought the steam fitter had got confused in his connections at the top of the tank, but the system had been in successful operation one winter. After finding this connection right we took down the cold-water pipe and found a piece of broom handle inside, which at first was a loose fit in the pipe, and it let the water past for a time, but had filled with sediment, with the results mentioned.

J. N. WOODRUFF.

W. Liberty, Ohio.

Stand-by Plant Supplying Steam to Central Heating System

The Northwestern Electric Co. operates an 18,000 horsepower hydro-electric plant on the White Salmon River. The plant supplies energy to the City of Portland, Ore. A reserve was needed in order to back up the water-power station. The plant installed is described by G. Broili, in the "Journal of Electricity, Power and Gas." It was found that in order to serve the public properly, either a storage battery or a steam plant would have to be installed. The steam plant was finally chosen because of the possibility of installing a central heating system.

Two 3500-kw. turbines were placed in the basement of a large Portland office building. These turbines operate noncondensing and act as voltage regulators on the electric end by varying the field excitation. The turbines can be made to carry enough load to furnish the steam required for the heating system, or the steam can be bypassed through reducing valves, or a combination of both can be used. As the turbines are always connected to the electrical system, they will quickly take up the load should there be any interruption of the service from the water-power plant. No delay can take place, such as often happens on many hydro-electric systems where the steam plant must be brought quickly into operation in emergencies. These turbines are ready to put out their full capacity at all times for an indefinite period, which is not the case with a storage battery.

In ordinary operation one or two turbines are run and all the steam required for the heating system goes through the turbines, carrying a part of the load. An automatic governor developed at the plant keeps the low pressure to within one-half pound of whatever is required. The plant has been operating successfully since starting. The boiler pressure is 185 lb. with 125 deg. superheat. The amount of superheat is greatly reduced in the turbines, but when any steam goes through the reducing valves, there is trouble in the heating main due to the excessive superheat. While a cold spray of water in the heating main beyond the reducing valve will absorb the superheat, experiments are in progress to perfect a system that will be more desirable.

The results obtained show that the central-station service is financially satisfactory, not to mention the item of service which is hard to estimate in money. Steam heat has been furnished for one year to an office building with 152,000 cu.ft. of space, and 1321 sq.ft. of radiation. In a previous year, the fuel cost was $438.40 and the labor cost $520, making a total of $958.40. The steam heat from the central station costs $520 for the year, thus making a saving of $438.40 over the fuel costs in the private plant. Another case is given of a well-built hotel, three years old, with 640,000 cu.ft. of space and 3650 sq.ft. of radiation. The fuel cost during 1913 in the private plant is compared with the net central-station steam cost for 1914 in the following table:

Month	Private Plant (Fuel only)	Cent. Heat. Total
January	$194.60	$145.58
February	174.65	118.58
March	124.75	80.00
April	99.80	67.86
May	99.80	55.10
June	24.95	31.50
July	24.90	40.50
August	49.90	44.01
September	49.90	71.28
October	99.80	99.50
November	123.75	123.53
December	212.54	132.43
	$1179.34	$1009.87

These figures show a fuel saving of $169.47, but in addition to this there was a saving made in labor amounting to about $1200 per year, making a total of about $1370. It will be noted that in the milder months of winter and in summer, central-station service exceeded in cost the amount paid for oil fuel for the private plant. This is explained by the fact that with central-station service better heating is enjoyed at all times and more hot water is used because of its being available, thus giving the hotel tenants a much more satisfactory service in every way.

The pressure in the heating mains is about 5 lb. Two 20-inch lines leave the station, and the sizes are gradually reduced. The lines are tied in with cross-lines wherever possible. Condensation in the mains averages about 0.025 lb. per hr. per sq.ft. of pipe surface and is practically constant regardless of the load or time of the year. Radiation of heat from the underground pipes is reduced to the lowest possible amount by the use of a very efficient insulation made to surround the iron steam pipe. First a layer of asbestos paper is carefully wrapped around the pipe, then an air space of about one inch is provided by centering the pipe within a heavy wooden-stave pipe casing. This casing is lightly banded with steel wire and painted with heavy tar paint. The interior is lined with bright tin to reflect radiated heat from the iron pipe, and between the tin and the wood is a sheet of asbestos to prevent charring of the casing. Expansion and contraction are taken care of by special joints known as variators, placed about every 50 ft. along the street trenches. The right-angled house service connections are taken off at the anchored point where needed.

To Calculate the Horsepower of a Stream of Water

The table gives the horsepower generated by one cubic foot of water per second (7.48 gallons) falling a distance of one foot, which is 0.0965 horsepower, or 72 watts, and is the basis upon which the following table was calculated.

HORSEPOWER GENERATED BY ONE CUBIC FOOT PER SECOND, FALLING DISTANCE 5 TO 200 FT.

Fall or Head in Ft.	Hp. of 1 Cu.Ft. or 40 In. Water	Kilowatts	Fall or Head in Ft.	Hp. of 1 Cu.Ft. or 40 In. Water	Kilowatts
5	0.483	0.360	35	3.380	2.521
6	0.579	0.431	40	3.860	2.876
7	0.676	0.504	45	4.340	3.237
8	0.772	0.575	50	4.820	3.595
9	0.869	0.648	55	5.310	3.961
10	0.965	0.718	60	5.790	4.319
11	1.062	0.792	65	6.270	4.677
12	1.159	0.865	70	6.760	5.042—5 kw.
13	1.255	0.936	75	7.240	5.401
14	1.352	1.008—1 kw.	80	7.720	5.759
15	1.448	1.080	85	8.210	6.124
16	1.545	1.152	90	8.690	6.482
17	1.642	1.225	95	9.170	6.840
18	1.738	1.296	100	9.650	7.198
19	1.835	1.368	125	12.070	9.004—9 kw.
20	1.932	1.441	150	14.48	10.802
25	2.410	1.797	175	16.90	12.607
30	2.890	2.890	200	19.31	14.405

Equivalents from this table may be converted to suit any case by multiplying the horsepower of 1 cu.ft. of water under any head by the head in feet times the number of cubic feet per second of water available.

For determining the flow of a stream, or the amount of water available for power purposes, the water is measured by means of a weir—an instrument quite well-known in all of the irrigating districts. A small weir table is appended.

TABLE FOR WEIR ONE FOOT IN LENGTH

Depth in In. on Crest	Quantity in Cu.Ft. per Sec. for Each Ft. in Length	In Miners In.	Depth in In. on Crest	Quantity in Cu.Ft. per Sec. for Each Ft. in Length	In Miners In.
1	0.08	3.2	7	1.50	60
1½	0.15	6	7½	1.66	66
2	0.23	9	8	1.81	72
2½	0.30	12	8½	2.00	80
3	0.40	16	9	2.18	87
3½	0.50	20	9½	2.35	94
4	0.65	26	10	2.55	102
4½	0.77	31	10½	2.75	110
5	0.90	36	11	2.93	117
5½	1.04	42	11½	3.15	126
6	1.18	47	12	3.35	134
6½	1.34	54			

This table was calculated for depths of water from one to twelve inches by one-half inch increments and for a weir width of one foot.

The Cost of Employing Incompetents

At a recent gathering of machine tool builders it was stated that it costs $30 to $35 to engage a workman, test him and discharge him if inefficient. This figure is based on the records of a large manufacturing plant, and it is easy to see how much can be lost per annum if great care is not exercised in selecting the new hands. It is even more necessary to be careful in putting new men on a power-plant staff, since an incompetent man may cause damage running into thousands of dollars in a very short time. The quality of the work done by a mechanic or machine operative can be very quickly gaged, but it is not so easy to estimate the abilities of a shift engineer unless he blunders right at the start. A keen chief will, of course, get to know the caliber of his man before very long, but an emergency may occur, and the mischief may be done before the discovery of incompetence has been made.

Heat Generated in a Circuit represents work done in overcoming the resistance of the circuit.

Ammonia a Heat Vehicle

By Albert Johnson

[The following paper by Albert Johnson, of the Herf & Frerichs Chemical Co., was first read before the American Meat Packers' Association, Chicago, and since then has been read before other like organizations. The explanations and presentation will commend it to those new at operating refrigerating equipment.—Editor.]

HOW AMMONIA CONVEYS HEAT

Let us see how anhydrous ammonia becomes a conveyor of heat. When one pound of anhydrous ammonia has passed through the regulating valve into the low-pressure pipes it remains a liquid until it can grab hold of from 500 to 600 B.t.u. of heat. Then the pound of liquid changes into a pound of gas. But it refuses to change from liquid to gas until that much heat leaves the room and enters the liquid ammonia on the inside of the coils, thereby turning it into gas.

The changing of the liquid into gas is what absorbs the heat. Therefore, it is always necessary to have plenty of liquid ammonia within the low-pressure pipes.

Do not, under any circumstances, allow gas to pass through the regulating valve, for then you only add heat to your rooms instead of subtracting it. Remember, the gas is the loaded vehicle, while the liquid is the unloaded vehicle, being empty. The liquid has plenty of room for heat units, but the gas has little room for heat units, since it is already loaded with them. It cannot carry any more. So it is well to watch and see that only liquid passes the regulating valve into the low-pressure pipes.

This is a more serious question in operation than you may think possible, and the subject is more fully covered in my former paper read before the International Congress of Refrigeration, and entitled "The Value of a Liquid Seal," which can be had upon application, free of charge.

Bear in mind that it requires heat to vaporize ammonia—the more heat, the quicker the evaporation; whereas, the less the heat, the slower the evaporation, which explains why "sharp freezers" are so apt to fill up with liquid in abundance, while the rest of the system may be suffering from the lack of liquid.

After the liquid has been changed into vapor by the heat, it has practically spent its energy as a refrigerant, for the gas has obtained its full load of heat and is ready to carry it away.

USE OF THE REFRIGERATING MACHINE

So far the ammonia, or vehicle, has been "running down hill," requiring no power. At the bottom of the hill is the loading platform where the heat is taken aboard. After this it's an uphill pull, and a good strong horse is required to pull it up to the unloading platform. The horse may be called a "refrigerating machine."

The machine gets behind the heat-laden gases in the frosted low-pressure pipes and pushes them up to the top of the hill to the unloading platform, or ammonia condenser, where the loaded gas is changed back into a liquid. Just at the moment when the gas becomes a liquid it releases or dumps out the heat that it formerly picked up in the rooms, and the water in the condenser then absorbs the released heat units and carries them away.

Thus we see how necessary is the refrigerating machine to push the loaded vehicle, ammonia, along the uphill grade of high pressures direct to the top, or unloading place, at the condenser. But that is all it has to do, for the real work of freezing is performed by the ammonia, not by the machine. The initial as well as the final operation is done by the vehicle called ammonia, which must not be forgotten.

Thus you can readily see how anhydrous ammonia actually becomes a so-called vehicle for removing heat units from insulated rooms and carrying them, with the aid of the refrigerating machine, upstairs or downstairs, around corners and angles to condensers, there to unload its heat. Then it goes back to repeat the operation.

WRONG NAME FOR A VALVE CAUSED TROUBLE

A regulating valve controls the flow of liquid ammonia into the low-pressure pipes. That is all it is there to do. It cannot do any freezing, since only the ammonia does that. I mention this because, way back in the early days of this industry, somebody misnamed that valve—the expansion valve—without thinking of the consequences.

Ever since then many operators got the erroneous idea that this valve actually did the heavy work of freezing, and they would fondle it and handle it, fuss over it and play with it, sometimes resetting it twenty times a day, then listening to hear the gas gurgle or spit through it. The misnaming of this valve has cost the owners of plants hundreds of thousands of dollars in time lost fooling with it and in lack of efficiency caused by relying on this valve during critical moments of climbing temperatures, when the receiver should be watched instead. It is best to call it a regulating valve, to save confusion of ideas, much money and false impressions.

When I speak of heat-laden gases in suction pipes it may surprise you. Try to put your hand on a frost-covered suction line and imagine it contains real heat. It actually does, and lots of it, only it is called latent heat, or insensible heat. A thermometer cannot register it, nor can you feel it by touch. But it is there just the same. Apparently, the pipe is very cold, for it is usually covered with frost, yet the cold gas inside of that pipe will deliver heat enough to warm up enormous quantities of condensing water from 10 deg. to 30 deg. F. per pound.

We learn how the vehicle ammonia is relied upon to take the initiative in the work of removing heat. It is essential to work with not only dry, but pure ammonia. Note the difference between dryness and purity, for volatile hydrocarbons may exist in the liquid itself, which cause abnormally high pressures. Such foul gases refuse to liquefy and they fill up the condensers.

These bad gases must be blown away. Hydro-carbon gases are both colorless and odorless, which makes them hard to find. They are hidden, and like latent heat we know them by the effect they produce when they refuse to liquefy, causing excessive fuel bills or power bills and great ammonia consumption.

It has been estimated that in order to purge 15 lb. of uncondensable or hydrocarbon gas from the system you lose 85 lb. of pure gas, because the two are closely associated or intermingled, so that when the purge valve is opened the good as well as the bad gases are liberated unavoidably together.

GOOD AMMONIA REQUIRES NO PURGING

Good ammonia requires no purging, for good ammonia is free from volatile hydro-carbons. The evaporation test does not disclose the presence of volatile carbon compounds, for they evaporate together with the ammonia. The working test seems to be the most reliable. The test for air in shipping cylinders means little as to quality and has the disadvantage of being deceptive.

Ammonia is like fullers' earth, because both require a working test to prove their effectiveness. In both cases results count more than analysis. A chemical report on fullers' earth is about as valuable as a chemical report on anhydrous ammonia. However, in making an exhaustive examination of ammonia a thorough chemist will demand to see the raw material as well as the finished product. In testing cement, for instance, a thorough chemist will also examine the clinker or raw material as well, in order to obtain data for proper valuation. The clinker may be overburnt or underburnt, and the chemist is right in demanding a sample of the raw material.

The purchase of anhydrous ammonia should be like the hiring of a man. You expect a man to perform some service and keep on doing so. In purchasing ammonia you must expect it to serve you by picking up or absorbing all the heat units possible and unloading them in large quantities day by day, without getting tired or worn out on the slightest occasion. Remember, you do not buy ammonia like other merchandise, to be sold to others from the shelf. Instead of that, you invest your money in an article that must work for you day and night, and produce results in heat-carrying capacity. For, to produce one ton of refrigerating duty the vehicle, ammonia, must fetch and carry away 288,000 B.t.u. of heat from insulated rooms in the shortest time possible, and that is why the question of ammonia as a heat vehicle is so serious as to affect the profits in a refrigerating plant.

New Electric Rate at Ottawa

Electricity for cooking at a price equal to 50c. gas is what Controller Ellis, of the Ottawa Municipal Electric Department, has attained for the city. The present price of gas is $1.25 per thousand cubic feet, less 12 per cent. discount, plus a $2 a year meter rental, or about a net rate of $1.20 per thousand cubic feet.

The annual report of the municipal electric department for 1914 pointed out the reduction in rates since the hydro-electric installation was first made. At that time the rate was 8c. per kw.-hr., less 10 per cent. discount, with no floor-area charge; whereas now the rate is 2c. net per kw.-hr., and 3½c. per 100 sq.ft., less 20 per cent. discount, for floor space, and 1c. net for excess current used other than for lighting.

American Association of Refrigeration

The annual meeting of the American Association of Refrigeration was held in the Hotel Astor, New York City, May 11 and 12. Inasmuch as the association interests itself more in the commercial application of refrigeration than in its technical and engineering side, operating engineers have little to gain from a knowledge of its activities other than to get a broad perspective of the state and advance of the application of refrigeration. To be sure, this is important and it is from this angle that the operating engineer should watch what the association is doing.

The meeting consisted chiefly of three business sessions and a banquet. As President Frank A. Horne, of New York City, was not present at the first session, Past-President Homer McDaniel, of Cleveland, opened the meeting.

In his address Mr. Horne approved the recommendation of the commission on legislation and administration that the association authorize the engagement of a reporting agency to keep the association in the closest possible touch with proposed legislation—local, state and national—affecting the refrigerating industry. Mr. Horne also recommended the engagement of a paid manager, who, working under the secretary, would devote his whole time to the affairs of the organization. That the president feels the need of more vigorous, extensive and complete committee work was evident from the manner in which he explained the need and value of committee reports.

BANQUET OF THE AMERICAN ASSOCIATION OF REFRIGERATION, HOTEL ASTOR

Dr. H. Dannenbaum, chairman of the committee on trade extensions, in his report stated that the reports of the Department of Commerce show that the value of ice and refrigerating machinery exported from the United States in the fiscal year ending June 30, 1914, was $978,457. Of this, Europe's purchases amounted to $34,883; North America's $271,843; Asia's, $100.010; South America's, $428,266; Oceania's, $138,091; and Africa's, $5364.

The Commission on Legislation and Administration requested Dr. Pennington and Dr. Barnard and Mr. Coe to draft a Federal storage law to be similar to the uniform cold-storage law already drafted.

The banquet, held in the College Room of the Hotel Astor, was enjoyable, and among the speakers were Borough-President Marcus M. Marks; Dr. Mary Pennington, chief of the food research laboratory of the Bureau of Chemistry and chairman of the association's committee on state and national investigations; G. Harold Powell, general manager of the California Fruit Growers' Exchange; and Homer McDaniel, a past-president of the American Warehouseman's Association.

All the officers, with the exception of J. H. Bracken, chairman of the testing committee, were last year's officers reelected: President, Frank A. Horne; vice-president, E. O. McCormick, Thomas Shipley, Homer McDaniel, Col. Jacob Ruppert, Jr., James Craig, Jr., Roderick H. Tait, R. H. Switzler; secretary, J. F. Nickerson; treasurer, John S. Field; chairman of Executive Committee, William J. Rushton; chairman of Advisory Committee, H. W. Bahrenburg; chairman of Committee on Papers and Lectures, Dr. F. W. Frerichs; chairman of Finance Committee, Theo. O. Vilter; chairman of Committee on Trade Extensions, Dr. H. Dannenbaum; chairman of Committee on State and National Investigations, Dr. Mary E. Pennington; chairman of Board of Engineers on Educational Work, Gardner T. Voorhees; chairman of Commission on Gases and Units, Prof. Edward T. Miller; chairman of Commission on Testing Refrigerating Machinery and Insulating Materials, J. H. Bracken; chairman of Commission on Application of Refrigeration to Foods, G. Harold Powell; chairman of Commission on Industrial Refrigeration, Peter Neff; chairman of Commission on Railway and Steamship Refrigeration, Carl Howe; chairman of Commission on Legislation and Administration, E. O. Whitford; chairman of Publication Committee, N. H. Hiller; chairman of Committee on Membership, Bruce Dodson; chairman of Press Committee, E. D. Ansley.

To Calculate Steam Required to Operate Pump

For a direct-acting pump in fair condition, operated at a piston speed of 100 ft. per min., assume an average steam consumption per indicated horsepower-hour of, say 150 lb. dry saturated steam, which is a so-called "water-rate" of 150 ÷ 60 = 2.5 lb. i.hp.-min.; and multiply this water rate by the indicated horsepower of the pump, as shown by the following:

Find the steam required to pump 9000 gal. of water per hour, from a shaft 450 ft. deep, using a simple direct, double-acting pump running at a speed of 100 ft. per min. and discharging through a 3-in. column pipe.

The effective head, in this case, is

$$h_1 = 450 + \left(\frac{9000}{60}\right)^2 \frac{450}{800 \times 3^5} = \text{say } 502 \text{ ft.}$$

The indicated horsepower of this pump will then be

$$H = 0.00034 \times 150 \times 502 = 25.6 \text{ hp.}$$

The weight of steam required to operate this pump, under the assumed conditions, will be

Steam consumption,

$$2.5 \times 25.6 = 64 \text{ lb. per min.}$$

—"Coal Age."

Recent Court Decisions

Digested by A. L. H. STREET

Rights of Water Consumers—A water company which shut off water from a customer's hydraulic elevator on the latter's refusal to pay an excessive bill, is liable for resulting damages sustained by the customer, regardless of whether the error in the bill was innocent or deliberate, according to the decision reached by the Court of Appeals of Kentucky in the late case of Louisville Tobacco Warehouse Co. vs. Louisville Water Co., 172 "Southwestern Reporter," 928. The court, however, upholds the right of a water company to make any reasonable regulations for the conduct of the company's business, including the cutting off of service for nonpayment of just charges which have accrued. But all regulations must apply to all persons similarly situated.

Duty to Install Lightning Arresters—An owner of an electrically propelled passenger elevator is liable for injury resulting to the operator from shock caused by lightning, if the accident be attributable to the owner's failure to install lightning arresters, according to the holding of the Springfield, Mo., Court of Appeals, in the case of Melcher vs. Freehold Investment Co., 174 "Southwestern Reporter," 455. Speaking of the measure of care to avoid injury resulting from use of electricity as power, the court declares that ordinary care requires the exercise of the highest diligence to take precautions against accidents, by installing such safety appliances as are reasonably available. And the decision adds that, since lightning arresters are well-known devices, an owner of an elevator who fails to install one cannot avoid liability for accidents of the kind mentioned by showing that other persons owning similar buildings have not installed them.

Suit for Flowage of State Lands—Suit was brought by the State of Minnesota against the Minnesota & Ontario Power Co., for $200,000 damages claimed to have resulted from flowage of 30,000 acres of state lands along the international border in the maintenance of the company's power dam across the Rainy River. The company, in addition to operating large pulp and paper mills in northern Minnesota, supplies electric light and power to various industries and municipalities. The state threatened another similar suit against the same company on account of prospective flooding of 50,000 more acres of public land near Kettle Falls on the same river, where the company is constructing another power dam. The suit brought, by omitting to claim any right to enjoin operation of the dam, recognizes the validity of the right granted to the company by the United States and Canada to maintain the dam.

Liability for Explosion of Boiler—An employer may be held responsible for injury to an employee, caused by explosion of a defective boiler after the making of repairs thereon, on the theory of negligence in failing to apply the hydrostatic test to the boiler, if that would have disclosed the defect. This is the holding of the Court of Civil Appeals of Texas, lately announced in the case of Ligarde vs. National Railway of Mexico, 172 "Southwestern Reporter" 1140, in which the plaintiff was awarded a verdict for $20,000, which the Court of Civil Appeals declares was not excessive, for injuries sustained by plaintiff in an explosion of a locomotive boiler in repair shops. The following statement of the court, bearing on the duty of inspection, would seem to apply to all classes of steam boilers:

> The engine was old, was in the shop for repairs, and it was the duty of appellant to apply all tests necessary to ascertain how much steam the boiler would sustain. The only perfect test was the hydrostatic, and the jury was warranted in finding that the railroad company was negligent in not applying that test.

Contributory Negligence of Engineer—A stationary engineer, who, being thoroughly familiar with the working conditions of machinery, fails to take proper steps to stop the machinery before placing his hands in a dangerous position, in making repairs, cannot recover against his employer for consequent injury, even though there may have been insufficient light in his place of work. This is the gist of the decision of the Supreme Court of Wisconsin, announced in the case of Hansen vs. Campbell Laundry Co., 151 "Northwestern Reporter," 262. The plaintiff was the engineer in the defendant's plant and found it necessary to tighten some nuts in the mechanism of a pair of automatic underfeed stokers. Instead of shutting off the steam by using one of the three valves, which he knew would absolutely close off the steam, he turned a dial point to zero, and supposing that would stop the machinery, reached his hand into a steel case containing movable mechanism. There was sufficient escape of steam past a regulating valve to cause the machinery to move, and his hand was injured in consequence. He brought suit to recover for his injuries, but the Supreme Court holds that the trial judge properly denied recovery on the ground of contributory negligence. The Supreme Court attributes carelessness to the plaintiff in failing to use the valves, as affording the only safe means of stopping the machinery, and finds that any insufficiency in lighting of the premises did not contribute to the accident by preventing the plaintiff from using the valves, or by ascertaining whether the dial point was at zero.

PERSONALS

C. E. Lesher, associate geologist of the land-classification board of the United States Geological Survey, has taken charge of the work of compiling the statistics of coal production published in the annual volume "Mineral Resources." This work has heretofore been directly under Edward W. Parker, whose resignation from the Geological Survey is effective July 1.

ENGINEERING AFFAIRS

A. O. S. E. Convention—The American Order of Steam Engineers will hold its twenty-ninth annual convention at Atlantic City, N. J., during the week commencing June 21. The local convention committee, assisted by the officers of the American Supplymen's Association, are hard at work completing the final arrangements. The Continental Hotel on Tennessee Avenue has been selected as the headquarters, and the elaborate mechanical exhibit will be located at the Morris Guards Hall, on New York Avenue.

A. S. M. E. Spring Meeting—The spring meeting of the American Society of Mechanical Engineers is to be held at Buffalo, N. Y., June 22 to 25. The society has met at Niagara Falls before, but this will be the first time at Buffalo. David Bell is chairman of the local committee of arrangements; James W. Gibney, vice-chairman; C. A. Booth, secretary, and C. H. Bierbaum, treasurer. The Engineering Society of Buffalo is to join with the local A. S. M. E. members and engineers generally in acting as hosts. The headquarters will be at the Hotel Statler, where all sessions will be held except the first one, which will be at Niagara Falls in the large auditorium of the Shredded Wheat Biscuit Co. The papers to be presented include "Laps and Lapping," by W. A. Knight and A. A. Case; "Model Experiments and the Forms of Empirical Equations," by E. Buckingham; "Rational Design and Analysis of Heat Transfer Apparatus," by E. E. Wilson; "Influence of Disk Friction on Turbine-Pump Design," by F. zur Nedden; "A Study of an Axle Shaft for a Motor Truck," by John Younger; "Corrugated Furnaces for Vertical Fire-Tube Boilers," by F. W. Dean; "The Effect of Relative Humidity on an Oak-Tanned Leather Belt," by William W. Bird and Francis W. Roys; "The Relation between Production and Costs," by H. L. Gantt; "Design of Rectangular Concrete Beams," by Howard Harding; "Some Mechanical Features of the Hydration of Portland Cement and the Making of Concrete as Revealed by Microscopic Study," by Nathan C. Johnson; and "Surface Condensers," by Carl F. Braun.

Chicago A. S. M. E. Discusses the Electric Locomotive—Friday evening, May 14, was the last meeting of the season for the Chicago Section of the American Society of Mechanical Engineers. As usual, the meeting was an informal dinner session in the Red Room of the Hotel La Salle. At a preliminary business meeting the following officers were selected for the following year: H. M. Montgomery, chairman; Joseph Harrington, vice-chairman; Robert E. Thayer, secretary; other members of the committee, Charles E. Wilson and H. T. Bentley. The subject for the evening was the "Electric Locomotive." It was a timely topic for Chicago and a goodly number of the engineers took advantage of the opportunity to learn what has been done and what is being done in this field. A. F. Batchelder, chief engineer of the locomotive department, and A. H. Armstrong, assistant engineer of the railway and traction department, both of the General Electric Co., gave talks of exceptional interest on the subject. The former confined himself to the design and by means of numerous lantern slides traced the development from the first locomotive installed by the Baltimore & Ohio R.R. Co. in 1895 to the recent combination passenger and freight locomo-

tives for the mountain divisions of the Chicago, Milwaukee & St. Paul Ry. The designs of truck, control arrangement, type of motor and other interesting features were illustrated in the numerous slides presented. Mr. Armstrong centered his talk on where the locomotive is used, the excuse for its existence and a comparison with the steam locomotive. He dwelt particularly on the Butte, Anaconda & Pacific 2400-volt direct-current locomotives, those of the New York Central and the immense machines recently built for the Chicago, Milwaukee & St. Paul Ry. Data on tractive effort, weight on drivers, efficiencies and limitations were given, and upon request were followed by an interesting summary on the development of current collectors. Both talks were highly appreciated by the audience, and no doubt valuable information was absorbed, which may help in the solution of one of Chicago's knotty problems—the electrification of its steam railways.

The National Association of Manufacturers will hold its 20th annual convention at the Waldorf-Astoria Hotel, New York City, May 25 and 26. Among those scheduled to address the convention are ex-President Taft, whose subject will be the "Clayton Act and Other Things;" Senator Warren G. Harding, of Ohio; Dr. Eugene L. Fisk, M. W. Alexander and Arthur D. Little. James A. Emery will outline the work of the newly created Federal Trade Commission. Walter Drew, of the National Erectors' Association, will discuss the work of the Federal Commission on Industrial Relations. Committees will report on fire and accident prevention, union label, immigration, uniform state laws, trademarks and copyrights, and industrial betterment. Incidental to the convention will be a unique exhibition devoted to various phases of industrial education with students actually at work in various lines of industries. In this will be included exhibits from New York City; Newark, N. J.; Fitchburg, Mass.; New Haven, Conn.; Altoona, Penn.; Detroit, Mich., and other places where well-known trade schools are established.

BOOKS RECEIVED

VALVES AND VALVE GEARS. Volume I. By F. D. Furman. John Wiley & Sons, Inc., New York. Cloth; 253 pages, 6x9¼ in.; 300 illustrations. Price, $2.50.

POWER HEATING AND VENTILATION. Part III. By Charles L. Hubbard. McGraw-Hill Book Co., New York. Cloth; 408 pages, 6x9¼ in.; 220 illustrations; tables. Price $3.

THE "PRACTICAL ENGINEER" POCKETBOOK AND DIARY FOR 1915. Distributed by the Magnolia Metal Co., New York. Cloth; 632 pages; 3½x5 in.; numerous illustrations and tables.

TRADE CATALOGS

Kerr Turbine Co., Wellsville, N. Y.—Bulletin No. 52. Economy turbo-pumps. Illustrated, 24 pp., 6x9 in.

Cresson-Morris Co., Philadelphia, Penn. Form No. 1001. Barometric condensers. Illustrated, 28 pp., 9x12 in.

The Richardson-Phenix Co., Milwaukee, Wis. Bulletin No. 40, Phenix oil and graphite cylinder lubricator. Illustrated, 4 pp., 8½x11 in.

The Draper Mfg. Co., Port Huron, Mich. Catalog No. 7. Valve facing tools, ball check valves, brass, iron and steel balls, pneumatic flue welders, pneumatic tube welders, etc. Illustrated, 40 pp., 6x9 in.

BUSINESS ITEMS

Negotiations were recently closed for the sale of the Cleveland Clutch Co. to the Reliance Gauge & Column Co., 5902-5912 Carnegie Ave., Cleveland, Ohio.

The contract for furnishing material under circular No. 891 for complete pumping plant for Dry Dock No. 1, Balboa Terminals, Balboa, C. Z., was awarded by the Panama Commission to Henry R. Worthington, 115 Broadway, New York.

August Mietz, 128 Mott St., New York, has recently secured orders for Mietz & Weiss oil engines from the Grinden Art Metal Co., of Brooklyn, N. Y. (2); the Town of Schleswig, Iowa (2); I. H. Pitts & Son, Waverly Hall, Ga.; Marcus Mason & Co., South Framingham, Mass.; George Buckley, Menlo, Iowa; U. S. Government, for lightships Nos. 101 and 102 (two 200-hp. direct reversible marine-type oil engines and four 50-hp. oil-engine air-compressor outfits).

NEW EQUIPMENT

ATLANTIC COAST STATES

The Cambridge Electric Light Co., Cambridge, Mass., has made application to the Board of Gas and Electric Light Commissioners for authority to issue $100,000 in additional capital stock, a part of which will be used for making additions to the system. W. E. Holmes, Newton, is Treas. and Gen. Mgr.

The Hudson Ice Co., 136 Oakland St., Jersey City, N. J., is preparing to build a 100-ton ice plant at Central and Jefferson Ave., Jersey City. S. H. McKnight is Pres.

It is reported that the Council has engaged W. S. Temple, Philadelphia, Penn., to prepare plans for the construction of a municipal electric-lighting system for Millville, N. J.

It is reported that the Town Council of Patton, Penn., is considering the establishment of a municipal electric-light plant. Service is now furnished by the Penn Central Light & Power Co., Altoona.

SOUTHERN STATES

It is reported that the Planters Oil Mill & Gin Co., Kosciusko, Miss., is in the market for additional power equipment and boilers.

The City of Oberlin, La., has appointed a special committee to engage an engineer to prepare plans for the construction of a municipal electric-light plant. W. D. Stockwell, Mayor, is Chn. of the Com.

CENTRAL STATES

The municipal electric-light plant at Ashley, Ind., was destroyed by fire recently at a loss of $4000. George W. Caryl is Mgr.

At a recent election in Chalmers, Ind., the citizens voted in favor of installing an electric-lighting system. It is reported that the plant will be constructed by a stock company, and will eventually be purchased by the town. T. C. Smith, Chalmers, is Engr.

The City Council, Lanark, Ill., is considering the establishment of a municipal electric-light plant.

It is reported that the Board of Public Works, Oshkosh, Wis., has been instructed to advertise for bids for a dynamo and connections for an independent lighting system for the new high school in Oshkosh.

WEST OF THE MISSISSIPPI

It is reported that the Iowa River Light & Power Co., Eldora, Iowa, contemplates spending about $50,000 for improvements to its system. A new power station will be built, and the output of the steam plant increased. J. C. Lundy is Mgr. and Cont. Agt.

The city of Shellsburg, Iowa is considering the question of establishing a municipal electric-lighting system. The estimated cost is $10,000. It is reported that the Cass Interurban Co. has also made an offer to build a transmission line from Urbana to furnish electrical service to Shellsburg.

The town of Marietta, Minn. is considering the question of establishing a municipal electric-lighting system.

The citizens of Kirwin, Kan., have voted in favor of a bond issue of $12,000 to be used for the installation of a municipal electric-light plant.

The town of Corder, Mo. has appropriated $6000 for the purpose of buying light and power equipment.

The city of Poplar Bluff, Mo., has voted $75,000 in bonds for the purpose of establishing a municipal electric-light plant. Contracts for the installation of the plant have been awarded.

L. B. Myers, El Reno, Okla., and associates, will establish, according to press reports, an electric-light and power plant and ice factory at North Pleasanton, Tex. The estimated cost is $40,000.

It is reported that the city of Seguin, Tex., will make improvements and extensions to the municipal light and power plant to include the construction of a new building and penstocks, the installation of a 187-kw., three-phase, 60-cycle, 2300-volt, waterwheel type generator, exciter and switchboards, two 150-hp. vertical waterwheels and transmission machinery. Owen A. Gofford is Mgr., Cont. Agt. and Supt. of the plant.

It is reported that Morris Sass, Ardmore, Okla., is in the market for power equipment, including a gasoline engine.

It is reported that the City Council of Reno, Nev., is considering a bond issue of $750,000 to be used for the construction of a municipal electric-light plant and water-works system. J. R. Parry is City Clk.

Bids will be received until May 28 by R. W. Davis, Mayor, Harrisburg, Ore., for one 35-hp. motor of 900 to 1300 r.p.m., one 25-hp. motor, 900 to 1200 r.p.m., and one 5-hp. motor of about 1500 r.p.m.

The City Trustees of Escondido, Calif., have decided to call a special election to vote on the question of a bond issue to be used for purchasing the property of the Escondido Utilities Co.

CANADA

It is reported that the city of Sherbrooke, Que., will purchase electric meters, controllers, etc., to the amount of about $27,000. W. E. C. Gatien is City Clk. No bids will be asked.

The Canadian Niagara Power Co., Niagara Falls, Ont., contemplates making extensive improvements in its plant. Philip P. Barton, Niagara Falls, is Gen. Mgr.

The City Council of Kelowna, B. C., is considering the establishment of a municipal electric-light plant, estimated to cost $120,000. It is reported that a bylaw will shortly be submitted to the rate-payers.